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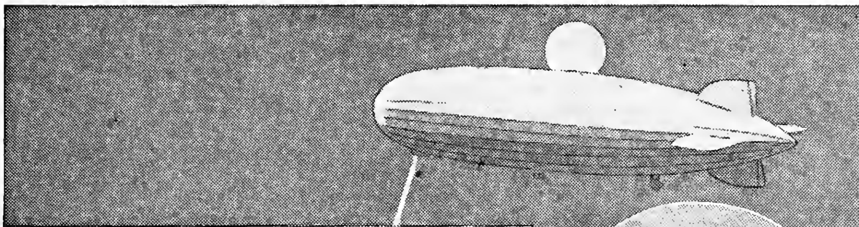
THE ARMOUR ENGINEER

NOVEMBER, 1932

MOUR INSTITUTE OF TECHNOLOGY, CHICAGO, ILLINOIS



Talking from the sky on a beam of light

THE huge U. S. Navy dirigible, Los Angeles, is roaring above the General Electric Research Laboratory at Schenectady. On board the airship, an almost invisible beam of light is aimed at a 24-inch mirror-target a half-mile below. The mirror, turning as it follows the dirigible's course, catches the slender beam. Voices transformed into electric impulses in the airship are carried to the mirror by light waves. A photoelectric cell picks up these waves and they are reconverted into sound, which is broadcast to the world by radio.

A "voice on the air," with a "voice from the air"—the official opening of radio station WGY's new 50-kw. transmitter is taking place. One millionth of a watt—generated from the blast of a police whistle in the dirigible—is transmitted to the ground on the beam of light and to a Thyratron tube. The tube magnifies the whistle energy 50,000,000,000,000 times to operate the switches that start the transmitter, five miles away.

(Insert) John Bellamy Taylor, General Electric research engineer, operating projecting apparatus

Receiving mirror on roof of General Electric Research Laboratory

Thus was "narrowcasting," a possible means of secret communication, recently demonstrated to Military and Naval experts by General Electric engineers. The future will demonstrate its commercial value. Electrical developments such as this are largely the accomplishments of college-trained engineers. They are leading the way to even greater progress in the electrical industry and are helping to maintain General Electric's leadership in this field.

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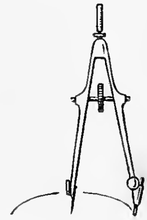

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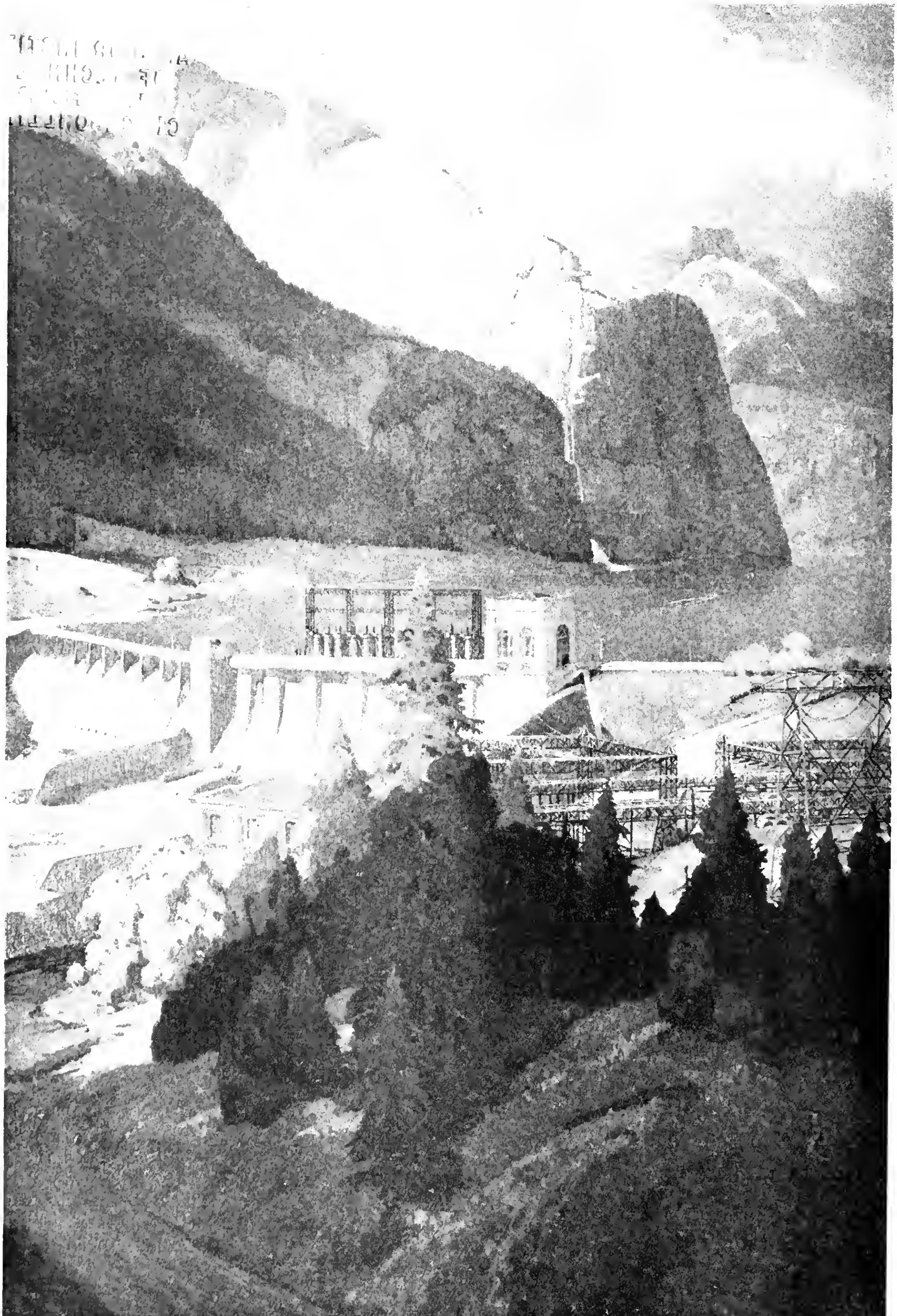

Man Improves Nature's Beauty

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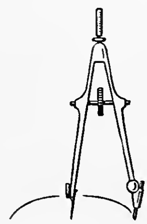

The Trademark as a Commercial Asset

By CHARLES W. HILLS, JR.

THE trademark is recognized as a powerful aid to commercial development. It provides the most efficient method by which the seller may distinguish his wares from those of another and effectively reach the customer by means of the printed page. The customer has learned to regard the trademark both as its owner's guarantee of quality and as a forceful weapon against fraud and imposition. Hence the law of trademarks is of vital concern to all.

When we trace the origin of the trademark we are led even beyond the early beginnings of commerce. The acquisition of property necessitated the employment of marks to identify ownership. The birth of commerce increased their use not only as indicia of ownership but also as distinctive marks of the products of different merchants. The ruins of ancient cities give mute evidence that such a practice existed among the early peoples. Archeologists have brought to us bricks from ancient Egypt and Assyria, charred loaves of bread from Pompeii, pottery from Egypt and lead water pipes from Ostia, all bearing

the marks or symbols of their maker or seller. Ancient stores, too, had signs posted in front of their doors to identify the owner. Later some of these signs were transferred to the goods themselves; and as the exchange of goods became more complex, this practice became more frequent.

Ancient commerce was of a purely personal character. As it was displaced by merchandising through agents or middlemen, opportunities for the pilfering of the good will of established firms greatly multiplied. The merchant became an easy victim of the trade pirate.

These conditions stimulated the use of trademarks, but the vast development of technical knowledge and skill, revolutionizing industry and creating extensive markets for manufactured goods, is to be witnessed before the trademark assumes its present role in modern commerce.

The now widespread use of trademarks is due largely to the changes brought about by the introduction of scientific production methods and machinery. This made it possible for the manufacturer to produce more goods than the local market he served demanded, and forced him to seek new markets for their disposition.

Business thus began to lose the personal character it formerly possessed. The seller no longer was in direct contact with his customer. He was not there to see that another's article was not substituted. He was now compelled to rely upon a chain of jobbers, wholesalers, and retailers whose interests were entirely foreign to his. He realized that some symbol of identification must be adopted if he was to reach the customer directly and protect his good will. The use of trademarks thus became a necessary adjunct to the development of business and the building up of good will.

Commercial wisdom dictates the intelligent use of identifying marks capable of exclusive appropriation and use. The trader must distinguish his article from a multitude of similar commodities that flood the market if he is to reach the buyer through the medium of advertising. Unless he does so, the benefit of his advertising is not reserved to him. Advertising soap without an identifying trademark necessarily benefits all persons who make or sell that article, but advertising "Ivory" soap creates a demand for soap carrying the trademark "Ivory," and the benefit of such advertising inures to the owner of the trademark "Ivory." The purchaser, too, must be provided with some means of identifying the product so that he may go forth into the market and unerringly select the particular article that he wants and avoid the one he does not desire. Unless this is done, the purchaser's favor is lost and the opportunity of building up a valuable good will is destroyed.

Therefore, the modern business man seldom, if ever, sends his products into the market without marking them with some mark of identifica-

tion even if only with his name and address. While the use of a name and address is a clumsy practice from many standpoints, yet such marking is better than none at all.

The kind of mark used for identifying purposes is most important. If the merchant merely uses his name and address, or if he adopts some symbol which others have an equal right to use, he will ultimately have to share the good will he creates with his rivals. But if the trademark is wisely chosen and is such as may be exclusively appropriated for use in connection with his merchandise, the good will which is built around such a mark becomes his exclusive property. Consequently, it is most essential that the trademark consist of a symbol which the law permits the first to adopt and use to exclusively appropriate. Such symbols are called technical trademarks.

Business men frequently confuse the technical trademark with the more general trade name. This is not surprising in view of the fact that even lawyers and judges frequently do not distinguish them with lucidity. The law, however, makes a clear distinction.

A valid trademark has been best defined as:

> "a name, symbol, figure, letter, form or device adopted and used by a manufacturer or merchant in order to designate the goods that he manufactures or sells and distinguish them from those manufactured or sold by any other; to the end that they may be known in the market as his, and thus enable him to secure such profits as result from a reputation for superior skill, industry or enterprise."

On the other hand, a trade *name* is a word or phrase used to designate a particular business, or the place where it is located, or an article of merchandise; but which is not capable of exclusive appropriation by anyone either because it is not affixed to the goods or because others have an equal right to use the mark. For example, "Kodak," "Lucky Strike," "Victrola," "Vaseline" or "Cellophane" are trademarks and "Wrigley's" or "Field's" are trade names.

The fundamental distinction between a trademark and a trade name is that in the case of the former the first to adopt and use has a perpetual right to exclusively use the trademark upon the goods to which he affixed it, or upon related products, which can only be lost by neglect or abandonment, while in the case of general trade names, no such right exists unless, or until, the name has been so extensively used and generally recognized that it acquires a secondary significance.

Thus it will be seen that the owner of a trademark can entirely prevent its use by a newcomer but the owner of a trade name can only insist that the later user so distinguish his goods as to avoid the probability of confusion in trade, and then only when his trade name has by long use in connection with the goods become to the public an indication of the goods of his manufacture or origin. So, when a com-

petitor began to use the trademark "Aunt Jemima" on syrup, the originator of the mark, who used it on pancake flour, was able to stop him, although he had never sold syrup and there was no evidence of probable confusion. Where a valid trademark is appropriated by another, evidence of probable confusion need not be shown. The court assumes that he adopted it for the purpose of trading on the first user's good will and that confusion will follow.

On the other hand, the one who first began to mark his products with the trade name "Coty" could only force the later user, whose name was Ernest Coty, to distinguish his product by using his full name accompanied by the phrase "not the original Coty." It is of course evident that this does not adequately protect the first user. Confusion is almost sure to follow, and the newcomer shares the existing good will as long as there is any confusion in the mind of the purchasing public. Such an attempt to distinguish between two competing products is not equivalent to completely prohibiting the use of the first adopter's mark. It is obvious therefore that a valid technical trademark is the most effective guardian of good will.

To be valid the trademark must function as an identifying mark and clearly indicate the origin or ownership of the goods; it must be applied to the article itself or to the wrapper or container in which the article is packed; it must be used in lawful commerce and not in violation of public policy, and must consist of a mark or symbol which others who are selling the same or similar goods cannot appropriate with equal right. All of these requirements are essential. If any one is lacking, the mark is not a valid trademark.

The prime purpose of a trademark is to distinguish the goods of one trader from those of another. If the mark does not perform this function, but instead, is used merely to distinguish one grade of goods from another, its user does not generally acquire trademark rights in the mark even though he complies with all the other requirements.

If the trademark is to perform its intended function of identifying a specific article, it must necessarily be affixed to the article itself, or to the wrapper or container in which it is packed. Hence the law insists that this be done. Failure to do so prevents the acquisition of trademark rights in the mark, even though the user may have complied with all the other essentials. So, it has been held that using a mark in advertising does not constitute a trademark use and the owner does not acquire a valid trademark.

The requirement that the mark be used in lawful commerce and not in violation of public policy is insisted upon by our courts for obvious reasons. Trademarks are protected by our equity courts, and if the trademark is used in an unlawful or fraudulent

manner its owner will be denied relief on the ground that those who seek equitable relief must come into court with clean hands.

Since the trademark confers upon its owner the exclusive right to use it upon the same or similar articles, the courts insist that such marks be chosen which competitors do not have an equal right to use upon identical or similar commodities. Such words, therefore, cannot become valid trademarks even if they are employed as guides to point out and distinguish the goods of one merchant from those of another.

Words which describe the characteristics, qualities or ingredients of the goods to which they are affixed cannot be exclusively appropriated as trademarks. So, too, words which simply indicate the style, superior excellence or popularity of the article, such as "First Quality" or "Superfine," or "Very Best" cannot become valid trademarks. Nor are words describing the purpose or use to which the article is to be put, or the effect produced by the use of the goods, capable of becoming valid trademarks. Every trader must be permitted to use freely the adjectives of the language in connection with his goods.

Such words cannot be converted into a valid trademark by merely misspelling them, as was done in the case of "Kid Nee Kure" for a medicine and in "Lather Kreem" for a shaving cream.

Geographical terms, too, fall into the same class. Every trader located at a particular place has an equal right to say that his goods were manufactured in that geographical location.

The same applies to personal names. All persons possessing the same surname have an equal right to use it in connection with their business, provided of course sufficient distinction is made to avoid trade confusion.

However, exclusive appropriation may be made of a *coined or invented word,* like "Kodak," "Mazola," "Vaseline," or "Texaco"; *a word or words,* used in an arbitrary manner, such as: "Good Luck" for oleomargarine, "Monarch" for coffee, "Beechnut" for food products; *a symbol,* as the Baker Chocolate Girl, or the Gold Dust Twins; *initials,* like "G.E." for electrical products; "B.V.D." for underwear; *a historical or mythological or imaginary person or thing,* as "Trilby" applied to ladies' gloves, "Atlas" for beer and "Bismark" for collars.

Such marks, may, therefore, become valid technical trademarks, provided that they are in compliance with all other essentials.

In selecting a trademark, not only should words, or symbols, subject to exclusive appropriation be chosen, but also careful consideration should be given to the likelihood of public appeal.

Words which are difficult to pronounce, not easily remembered or spelled, or unattractive in sound and

appearance, should not be adopted. Likewise, a mark which cannot be easily affixed to the goods or to the containers should not be selected.

Moreover, a mark which has been previously appropriated by another for the same or related products must not be chosen. To do so may involve the later user in a suit for trademark infringement and may result in serious financial loss.

When a mark or symbol which meets all legal and commercial requisites has been decided upon, its propriety alone does not create trademark rights in its originator or in the person intending to use it. In some of our states, the person who intends to use a commercial mark is protected by legislation, provided that the person comply with the provisions set forth in the respective law; but the common law demands more than mere adoption or intention to use.

The law requires that the mark must be actually used in commerce. The mark must be affixed to the article itself, or, when that cannot be done, to the container, and the article so stamped must be sold or actually sent into the market to be sold. The first person who does this is recognized as the first adopter and user of the mark and acquires the exclusive right to use it upon the article to which it was applied and upon related merchandise.

It is not necessary that many articles be sold. A single sale of an article stamped with the trademark, accompanied by circumstances clearly showing an intention to continue the use, has been held to satisfy the law, and sufficient to establish the right to exclusively use the mark, providing the trademark is not at the time used by another upon the same or similar products.

The exclusive right to use the trademark can be acquired only by some person who has some direct connection with the property in the goods to which the mark is applied. This is so because the sole function of the trademark is to indicate the origin or ownership of the goods. Hence, a salesman cannot acquire a trademark upon his employer's product. But a manufacturer, retailer, dealer, jobber, or persons who merely select or sell the goods made by others can obtain valid trademarks. Likewise, exporters, importers, and other persons who occupy a similar relation to the goods may become entitled to the trademarks which they may adopt and use.

The owner of a valid trademark has a perpetual monopoly, not in the mark itself, nor upon the unpatented article to which it is affixed, but only upon the right to use his private mark in connection with the merchandise to which he applied it, or upon related commodities. He can only prevent the use of his mark by other traders upon the same or similar goods, or in any manner which would be likely to mislead or confuse the public as to the origin or ownership of the various products. The trademark owner has the right to prohibit its use only in so

far as it may be necessary to avoid possible confusion and to protect his good will.

Thus, anyone is free to use "Coca-Cola" or "Kodak" or "Vaseline" in his writings. So, too, for example, the public may in the absence of patent protection make a trademarked product but there it must stop. To permit one to go further and mark his product by the trademark of another, such as his camera "Kodak" or his petroleum jelly "Vaseline" would enable him to divert trade which rightfully belongs to the owners of these marks. It would also permit him to defraud the public. The purchaser would be getting the goods of the later user thinking he was buying the goods of the former.

So, while the competitor is free to make or sell the article itself, the law requires him to adopt a trademark which is neither the same nor so similar that it would be likely to mislead the public. Our courts of equity will not permit such immoral and unfair practices. Our laws demand that no man shall represent or sell his goods as those of another. Every man must establish and trade upon his own reputation, and not upon that of another. It is upon these principles that trademarks are protected.

What the courts protect is not the chosen mark itself, but the good will which the mark symbolizes. Good will is property. Translated in dollars and cents the good will is frequently more valuable than the physical property of the business. The trademarks "Sweet Caporal," "Climax" and "Old Judge" were valued at forty-five million dollars when the American Tobacco Company was dissolved. In recent years the trademark "Gem" brought $3,600,000 while the company's physical assets sold for only one-ninth as much, or $400,000.

Good will is adequately protected by preventing the use of the same or similar symbols by another upon goods of the same class. A non-commercial use of another's trademark can do him no injury. Nor, generally speaking, can injury result from such a use upon non-related products, for in them he can have no good will. Therefore, the law limits the trademark monopoly to the use of the mark upon the same or related products.

This monopoly exists as long as the business lasts. If the business in connection with which it was used is destroyed, the trademark which symbolized it necessarily falls; and the right to its use is lost.

It may also be lost by voluntary abandonment, or willingly permitting others to use it upon identical or related products.

Sometimes, a trademark is lost because it becomes generic for the article to which it is affixed. Aspirin is such a case. The Bayer Mfg. Co. owned that term as a trademark for a certain drug. It sold the drug to manufacturing druggists, who made it up in tablet form and sold it to the public under the name of Aspirin. The Bayer Mfg.

Co. made no objection for about ten years, when it decided to stop such uses; but it was too late then. The public had learned to call that drug Aspirin. To the public Aspirin did not signify the goods of a particular trader. On the contrary, it meant the name of a particular drug. Hence, everyone was free to use it. A valuable trademark was lost primarily because its owner was not sufficiently vigilant in its protection.

Owners of trademarks must exercise caution in their use if valuable rights are not to be lost. Constant vigilance must be maintained to prevent their use by others upon identical or related products if the good will which clusters about the marks is to be preserved and enhanced.

The right to exclusively use a trademark does not depend upon any statute. It rests upon the common law which has long recognized and protected them. Congress, for the first time, passed a statute in 1870 which required that all trademarks be registered, but this statute was declared unconstitutional on the ground that Congress had no authority to legislate relating to marks not used in interstate commerce. Another act was passed by Congress in 1881, and this was amended and greatly enlarged in 1905, this time limited to trademarks used in interstate or foreign commerce. The statute does not create a right to use, but merely provides for the regulation of trademark rights acquired by virtue of the common law. A trademark, therefore, need not be registered, but it is advisable to do so whenever possible.

The registration of a trademark under the Act of 1905 creates a prima facie presumption that the trademark is valid and that it was adopted and used in interstate commerce. These presumptions are very helpful when the chosen mark is placed in jeopardy by litigation. Frequently it is difficult to prove the earliest date of adoption and use, especially after a lapse of many years. Records might be lost or destroyed; it is the first date of adoption which is most important in establishing the right to the trademark, for it is the first adopter and user who owns the trademark.

The registration of a trademark serves as constructive notice to the public of its owner's rights. By applying for registration, the owner of the mark has the advantage of having his mark published in the Official Gazette of the Patent Office. Such publication gives his mark publicity and tends to bring out objections, if there are any, to its registration. In this way the selector of the mark becomes fairly certain that his mark does not conflict, not only with a registered trademark, but also with the principal trademarks in use.

By registering the mark, its owner acquires the right to sue in the Federal Courts if it is infringed by use on goods sold in interstate commerce. When a mark has been registered, the importation of merchandise bearing

an infringing mark may be prohibited by simply filing a copy of the trademark certificate with the Secretary of the Treasury. The advantages accruing from registration have prompted leading manufacturers to register their trademarks in the United States Patent Office. If the mark is used in interstate or foreign commerce it should be registered.

Generally speaking, all technical trademarks used in commerce between the states, foreign countries, or with the Indian tribes may be registered in the Patent Office. But if the mark is identical or similar to a registered or known trademark previously appropriated to goods of the same class, it will be denied registration. Geographical and descriptive marks may not be registered. Likewise, the name of an individual or corporation may not be registered unless it is printed or woven in a distinctive manner, or the portrait of the individual is used with it; a portrait of a living individual cannot be registered without his written consent. The flag or coat of arms of the United States, or of any state, municipality, or foreign country cannot be registered. So, too, the insignia of the American Red Cross Society, or any design or picture which was previously adopted by a fraternal society as its emblem, will not be admitted to registration.

However, any trademark, even though it is descriptive, geographical, or a proper name, may be registered if it has been in actual and exclusive use by the applicant or by his predecessors in interstate or foreign commerce or in commerce with the Indian tribes for ten years prior to April 1, 1905.

In 1920 Congress passed another act relating to trademarks. This act permits the registration of any mark not registrable under the 1905 act, provided that such mark has been in use for not less than one year in interstate or foreign commerce, or in commerce with the Indian tribes. The purpose of this act was merely to provide a basis for foreign registration in those countries which require domestic registration first. Registration under this act has been held to create a prima facie presumption that the mark is descriptive. Hence, no mark should be registered under the 1920 act unless it is not registrable under the 1905 act, and then only if it is necessary to do so in order to secure foreign registration.

Trademarks should be protected in every way possible as they offer surprising investment opportunities in modern commerce, and their use has become a settled policy of the business world in affording the most effective device for connecting the advertisement with the merchandise. Thus it serves as a potent sales instrument and as a tool for the creation and extension of a valuable monopoly based upon public favor, which can only be destroyed by willful neglect or abandonment.

Science, The Basis of Engineering

By PROF. CHARLES E. PAUL

THE physical sciences, fortified by mathematics, are the foundation of all engineering studies. Applications of the principles of the sciences fundamental to engineering are responsible for a major part of our present state of civilization. Industrial development, civic betterment, transportation facilities, the comfort and pleasure of the individual, and many other advantages of this period are to be credited primarily to science. In fact, engineering has been defined broadly as "the science of controlling the forces, and of utilizing the materials of nature for the benefit of man, and the art of organizing and directing human activities in connection therewith."

Crude practices and processes have been refined, rough materials replaced, cumbersome machinery and apparatus improved, slow procedure made more rapid—all for the industrial advancement and comfort of mankind. These changes have been brought about by the engineer. The accomplishment was made possible through the application of his training in the fundamental sciences, aided by his ability to reason and apply the results of experience and research in his particular field of activity.

Aim of the Department of Science The Department of Science at Armour Institute of Technology was founded as a part of the "Armour Plan." The aim of the course of study offered by the Department is to provide a thorough training in the sciences relating to engineering, and a more extensive knowledge of the humanities than is customary in the usual engineering course. It prepares the student for scientific research, either pure or as applied to industry, and provides a broad training of extreme value as preparation

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Editor's Note: *The Department of Science at Armour Institute of Technology was established in September, 1932, as a part of the "Armour Plan." A majority of the work of the course offered by this new department is given in the departments of Mathematics, Physics, Mechanics, and Chemical Engineering. A wide choice of electives from other courses is possible during the senior year. Professor C. E. Paul is in charge of this department.*

for teaching, consulting engineering, or for duties of a specialized or executive nature in industry.

A large proportion of the students who enter engineering schools each year have no definite purpose in following the course which they indicate on their entrance papers. Many of them choose a course without careful thought as to the kind of work covered by it, their degree of interest in such work, or the possibility of success in it as a vocation. But few have had the counsel or contacts which enable them to make such a decision wisely. They all feel that they wish to become engineers, but the difference in training in the specialized lines and the divergence in practice after graduation is not recognized until they are well advanced in their period of training. Others desire a general training in the sciences upon which engineering is based, together with a wider individual choice of engineering subjects than is allowed in any of the usual specialized courses. They also wish to devote more time to the study of physics, chemistry, mathematics, mechanics, English, modern language, psychology, economics or history.

These types of students find the course in Science well adapted to their needs and ideas, because of its close relation to the specialized engineering courses during the first two years, the larger number of hours devoted to scientific and humanistic subjects, and the wide choice in electives offered during the fourth, or senior year. If graduate or fifth year work is contemplated, the electives provide an opportunity for either more intensive specialization in mathematical or scientific work, or a broader knowledge in subjects pertaining to one or more of the usual courses in engineering.

The length of the course is four years, and the degree of Bachelor of Science is awarded upon its successful completion. If the graduate wishes to remain for a fifth year of work, he is awarded the degree of Master of Science upon successful completion of this additional year of work. The fifth-year work is also available to graduates of other colleges who have the proper qualifications.

Subjects Offered in the Course The subjects offered in connection with the usual courses in engineering are divided into four principal groups: the fundamental sciences, the fundamental engineering subjects, the humanities, and the special or professional studies.

The fundamental science group, which includes physics, chemistry, mathematics, astronomy, biology, and geology form the basis upon which engineering principles are established. The engineer must be a man thoroughly trained in science. All engineering specialties are based upon the same fundamental sciences. They differ only in the application of these basic principles to different fields of work.

The fundamental engineering sub-

jects are the primary application of the sciences to engineering problems and practice. These studies are general in nature and appear in nearly all courses. They embody analytical mechanics, electricity and magnetism, drawing and design, mechanics of materials, hydromechanics, thermodynamics, etc.

The humanities group includes English, modern language, history, philosophy, psychology, and usually economics. In recent years it is becoming more common to consider economics as belonging to the fundamental science group on account of the growing economic importance of engineering work in all industrial and commercial activity.

The new "Armour Plan" calls particular attention to the importance of the humanities as a part of the education of the engineer, and proposes changes in curricula which will provide a greater knowledge of the humanistic subjects.

An examination of the curriculum of the Department of Science will show that the aims of the course have been attempted by an increase in the hours devoted to the fundamental science group and the humanities over those offered in the usual courses in engineering. Recognizing the fact that many students enter all of the courses in an undecided state of mind and "find themselves" later, the first year of work is planned in such a way that students can change from the Department of Science to one of the departments of engineering or architecture, or conversely, at the end of, or during, the freshman year without serious difficulty. After the first year, the change in either way would become increasingly difficult on account of the divergence of the various courses along specialized professional lines.

When the student has reached his fourth or senior year, he will know with reasonable certainty whether he is mainly interested in scientific research, teaching, or in engineering as applied to commerce. At this time, he is allowed to complete his course along one of two lines—general science, or general engineering. The wide choice of studies offered in the curriculum makes this possible since special and professional scientific and engineering subjects have been grouped as electives to be chosen during the senior year, or as graduate work. The choice of these electives by the student is to be approved by the director of the course and the heads of the departments comprising the Department of Science.

Shop-practice courses have been omitted entirely from the course in Science. An amount of drawing sufficient to make the student familiar with the principles of working drawings, correct drafting technique and lettering, is given during the first year.

Hours gained by these eliminations have been used to amplify the course along humanistic and scientific lines.

The course is not an easy one, and requires as many hours of preparation and recitation as in the specialized courses in engineering. It is not a refuge for the student who desires to apply too flexible a type of college life to attaining an education in engineering. The advantage of the university is present in the latitude of scientific, humanistic, and professional electives offered, but a well-filled program of study and work is necessary for successful accomplishment.

Kind of Work Open to Graduates It is probable that many of the students who elect the course in Science and continue in it through the entire four or five years of work will plan to enter some phase of technical research. The field of investigation in pure or applied research is endless. The results of such work in the past surround us. The value of its future is becoming more apparent to industry each year.

Others may desire the broad training in science and the humanities given in the four-year course as a background for specialized subjects in engineering to be taken in a fifth year of study to prepare themselves for some highly technical branch of a given industry.

A natural inclination toward the consulting side of the profession may become aroused in the student during the later years of the course and he may decide that his choice of general engineering subjects, economics, and a sound training in science has prepared him for a career in this commercial field.

Many of the larger industrial organizations, both commercial and financial, have found from long experience that the technically trained graduate is of great value to them after they have trained him to apply his education to the activities of distribution, administration, or appraisal in their field. The length of the period of training depends mainly upon one of two things—either the degree of specialization to be mastered, or the breadth of fundamental training acquired by the graduate. The course in Science provides this breadth of training.

If the claims of many of our leading economists are given serious consideration, the question of balanced production and distribution in the industrial field must be met if we are to regain and maintain commercial prosperity. The advance in technical training has resulted in simplified and multiplied production in industry. The creation of supply has proceeded more rapidly than the absorption through demand. A better balance must be obtained. This condition presents a vital problem for the scientifically trained technical graduate. The better his understanding of economic principles as related to industrial matters, the more effective will be his part in this adjustment. Industry has a place for men of this type in both minor and major executive positions.

Some may find that they wish to teach, either in scientific or technical branches of study. The possibility of combining teaching with a limited amount of scientific or industrial research may appeal strongly to them. Specialized consultation combined with teaching is followed by members of the instructing staff in most of the leading technical schools of the country, generally to the advantage of the instructor and his students, as well as to the credit of the institution.

Personal Characteristics for Success

The basic qualifications for success in the fields open to the graduate in Science are practically the same as for specialized engineering. Such fundamentals as excellent moral standards, high ideals, self discipline, industry, initiative, and good judgment are assumed. In addition to good health, breadth of interest, elements of leadership and the ability to express ideas clearly, the following technical qualities should be indicated to a marked degree in those who are to specialize in research:

Outstanding ability in mathematics and the physical sciences.

An analytical mind to critically study technical problems and arrive at their correct solution.

Interest in abstract and difficult problems.

An inquisitive mind which seeks reasons for all things.

Enjoyment in working with inanimate things.

Originality of thought and action.

A thorough knowledge of the theoretical side of the sciences and their basic mathematics.

If the student believes that he has, or is capable of developing, these necessary qualifications, he should assure himself to a reasonable degree that his vocation is worthy of his best efforts and is permanent in character. Also, that he will be happy in doing the kind of work involved. He naturally looks for pecuniary rewards, and desires to enter a profession that is growing stronger through its value to industry and society.

Practical Research in Industry

The scope of the practical problems in industry which are to be solved by the application of fundamental scientific principles is too large to consider here. We repeat that engineering is the intelligent application of basic scientific laws. There is a rapidly growing tendency in industry to divert the attention and activities of the technical graduate from the clearly mapped paths of practice in his chosen specialty, and encourage him in investigating new roads of professional and industrial progress. From the laboratories of these investigators have come many of the developments which have revolutionized our habits of thought as well as our mode of living. As a result, a demand has developed for practical minded men trained to find new ways of applying scientific knowledge. With these needs of industry in mind, the growing importance of a general training

in the basic sciences involved in engineering is urged upon the technical schools by many prominent executives in the industrial field.

Every industry has its special problems. The following are a few of the many examples:

Ability of metals and alloys to stand repeated workings; air propelling mechanisms and air conditioning apparatus; aluminum products and utilization; application of asphalt and petroleum to commercial purposes; automobile materials, treatment, application, etc.; by-product utilization; casting of metals; cement products and their application and use in construction; ceramic investigations; coal tar products; conveying of dust and waste materials; corrosion of steel and iron; design and mechanical properties of packing boxes, crates, and methods of packing; development of adhesive products and sizings; development of refractory materials; dyes; explosives; fertilizers; fire protection engineering problems; fluxes and alloys; food products and processes of food manufacture; fuels of all kinds; fusing together glasses of different types; graphite products, including dry-cell filler, paint pigment, polishes, pencils, electrodes, and lubricants; heat treatment and cold drawing of steels; heat treatment of non-ferrous metals and alloys; heating and ventilating problems; high temperature paints; hydraulics and hydrodynamics; illumination problems; improvements on cutting tools, alloy steels, and special steels; induced draft for combustion of all kinds of fuels; insulation of high-tension automobile ignition apparatus; investigations along different aeronautical lines; magnetic testing and research; manufacture and distribution of gas; manufacture of steel; metallurgical research; mill processes connected with pulp and paper making; new forms of electric lights and the improvement of existing forms; paints and varnishes; petroleum products; photographic and projection apparatus; photography; practical methods of applying and using stucco and cement; problems arising in connection with the manufacture of rubber products; problems in welding; problems which involve crushing, grinding, pulverizing, mixing and sifting machinery; pulp, wallboard, asphalt, and gypsum products; radiators; induction, convection, radiation; radio telegraphy and telephony; rare metals and their use in industrial alloys; refrigeration; resistance materials and insulation; rust-proof paints for iron and steel; special machinery and processes for mechanical, electrical, textile and chemical trades; study of materials of engineering, such as water, fuels, metals, cements, paints, and clays; tanning and tanning materials; telephony; treatment of boiler feed water; waste recovery; waterproofing paints and processes; wind tunnel tests of wings, bodies, propellers, etc. in connection with airplanes; wireless transmission development; wrapping and protecting food products.

Future Prospects in Industrial Research

While the value of this type of broad training is apparent to those who wish to enter business or to teach, it is outstanding to those who contemplate entering the growing field of industrial research. This is stated clearly by John Mills, Personnel Director, Engineering Department, Western Electric Company, in a publication issued by the National Research Council. Mr. Mills says:

"Individuality of aim, of opportunity, and of reward; wide personal and scientific contacts; group stability and stimulus; these are the outstanding advantages to the individual of association in the technical staff of the modern industrial research laboratory. Many successes have been made and more are under way in this field of industry.

"The original successes accrued to the first comers who were enticed from academic surroundings in part by the spirit of adventure, by the opportunity of research uninterrupted by teaching, by increased remuneration, and in part by a larger vision of the ultimate possibilities of industrial research. Their choice of science as the field for their endeavor had been at a time when almost the only research activities were those in connection with teaching, and research was but inadequately rewarded in money. Whatever other potentialities they had as executives or business administrators their common interest and ability was as creative scientists. Today, as well as yesterday, the industrial laboratory—and there are over 500 such laboratories, counting little and big, in this country—seeks the man with creative instincts and a broad training in theory and experimental technique. To such men, with the added abilities of effective cooperation and leadership, industry will continue to offer exceptional opportunities for service and responsibility and for prestige and reward."

Vital Considerations in the Development of Illinois Municipal Water Systems

By JAMES G. COONEY

THERE are in Illinois 1,123 incorporated cities and villages. Of these 523 have public water supplies. Of these 67 are privately owned, and 456 are municipally owned.

All of the cities and villages in Illinois above 4500 in population have public water systems. Of the cities in Illinois having a population less than this, it is estimated that 480 have public systems, and that 612 are without water systems. With eight exceptions, all the incorporated municipalities in Illinois above 2000 in population have public water supplies.

During normal times the number of municipalities without water systems gradually decreases from year to year. Thus public health, convenience, and safety are improved; better fire protection is assured; a savings made in insurance rates and fire losses; and the industrial progress of the communities involved, is hastened.

The 523 municipalities in Illinois having public water supplies are in constant improvement so far as their water systems are concerned. Distribution systems are being extended; sources of supply are being found inadequate and unsatisfactory; and the prevailing tendency toward municipal ownership of waterworks results from time to time in the purchase of existing privately owned plants by the municipalities they serve.

So we have in the field of municipal water systems, as in all other human activities, a constantly changing world.

In this field of human endeavor, as in so many other fields of human activity, the engineer plays an important part. But in his rôle of aiding his fellow men in the construction of water systems where none now exist, in his rôle of improving and enlarging existing water systems, he is confronted with problems of finance, not of his making; nor are their obligations set out in his textbooks; nor can they be solved on his slide rule. As

so often the engineer is the first on the ground, and so often the motivating force behind public improvements, it behooves him to familiarize himself with the intricate field of finance as it affects and makes possible his endeavors to add to the health, convenience, and safety of the human race. If he cannot lead the way in this contributing field of finance, the engineer can be, if he will, at least able to point out the right paths, and designate the specialist best qualified to lead and advise.

The financial considerations involved in the construction and improvement, and the purchase of water systems by municipalities, are frequently of greater importance, and present greater obstacles than those of an engineering nature. But in the discussion to follow, of the financial considerations involved in the promotion of municipal water systems, the writer can only point the way, warn of the dangers, and suggest the paths to take, as well as the leaders to choose.

If we interpret an engineer's responsibilities within very narrow limits, he cannot be held to account for the improper financing of a municipal water system. He cannot, however, escape the moral responsibility of over-ambitious, extravagant, and plainly dishonest financing of municipal water systems, where he has advocated or even acquiesced in such schemes. Eventually, he will lose both his reputation and his practice, if he persists and assists in the overcapitalization of public improvements coming under his jurisdiction.

Abuses in the financing of municipal water systems are confined, for the most part, to the smaller cities and villages, and to those cities and towns which have employed some type of revenue bond for financing purposes. Such abuses as have occurred have been possible because neither of the water revenue bond statutes place any direct specific limit on the amount of the bonds which may be issued on a project, and the municipality is not legally bound to support the revenue bond issue with tax receipts. Consequently, the temptation has been great for public officials, engineers, attorneys, contractors, bond brokers, etc., to build or purchase water systems for municipalities requiring issues too large for the revenues available. The result has been the defalcation of many water revenue bond issues, with subsequent loss of principal and interest to the security holders scattered throughout the country, who, for the most part, are inexperienced investors. Such a state of affairs is deplorable, and is a poor advertisement for the municipalities of the State of Illinois. It has cast a suspicion on all water revenue bonds, lowered their value, and restricted their market.

If these defaulted securities were in "strong" hands, it might be possible to obtain the deposit of the securities of a number of defaulting

Public water supplies in Illinois, except in Cook and Du Page Counties.

municipalities and by a group management, together with higher rates where the rates are obviously too low, eventually give the holders of such securities some return on their investment. However, the time and expense required to locate the holders of such securities, due to the fact that such bonds are frequently peddled about the country by free-lance salesmen or doubtful bond houses, clouds the practicability of this suggestion. Furthermore, the water systems on many of these defaulting municipalities were so grossly over-capitalized, and their construction so defective and improperly designed, that the problem of their financial and structural rehabilitation is quite hopeless.

In any case, the best protection for the municipality is the retention of an engineer of unquestioned integrity and ability, and the best protection for the buyer is to buy only from established bond houses, with a good record void of defalcations. If the security purchaser contemplates a large purchase of revenue bonds, it is most certainly sound practice to spend a few hundred dollars in checking up on the soundness of the issue. It is astounding that bond houses, who frequently purchase large issues of bonds, do not adopt the precaution of retaining a hydraulic engineer of ability and integrity to check the present and potential earnings of the municipal water system, whose issue is intended to be sold to their unsuspecting clientele.

In order to retire twenty year five percent bonds, an annual sinking fund of nine percent is required. In financing a municipal water system, it is desirable, and it is frequently possible, to have the first bond mature five years after the date of issue. Therefore, if the ratio of net earnings to interest on the funded debt in the fifth year, be in the ratio of 1.5 to 1, it can be seen that sinking fund requirements have been met, as the annual net profits shall be at least twice the maximum annual interest requirements on the funded debt of the corporation. The deficiencies incurred during the first four years' operation should be made up during later years, assuming that the water plant had only just met the requirements for this term of operation.

Despite the number of defalcations in Illinois Revenue Bonds, there is still a moderate market for them and they bring a fair price—where the revenue is unquestionably large enough to cover annual sinking fund requirements with a good factor of safety. As has been stated elsewhere, water revenue bonds offer the only means of financing the purchase of private water systems by municipalities of average population.

The domestic consumption of water varies but little. Water is indispensable to life, health, safety, and cleanliness. In smaller communities, private wells are common and consumers can and do cut off from the public supply during the periods of finan-

cial stress, and especially during the summer months. In larger municipalities private wells are uncommon, and the use of the public supply is, with a very few exceptions, a year round affair. So far as the industrial consumption of water is concerned, there will not be as great difference in its consumption between periods of prosperity and depression as in the case of electric power.

Testifying to the soundness of water supply securities of the better grade, earnings and related statistics for representative water systems, both private and municipal, can be had for many of the various plants.

Among the engineering considerations, we shall first consider the construction, or, more correctly speaking, the promotion of a complete water system for a small community, not having one at present. We are not concerned with all of the details of design that enter into the plans for such a project, but only with the more fundamental problems that are of most interest to the public official and the property owner, and which form the "corner stone" of the engineer's plans and calculations.

The first step which a municipality should take to consummate its desire for a municipal water system, is to have a so-called Preliminary Report made by an experienced hydraulic engineer, or firm of engineers, who has an established record of successfully engineered and successfully financed plants of a similar size. It is unfortunately true that municipalities will seldom take the trouble to even write or phone, to say nothing of making a personal visit, to other municipalities where the applicant-engineer has been retained on a similar project. Where the municipality has been fortunate enough to retain an engineer of ability and integrity, it is assured of getting a competent preliminary report. It must be realized, however, that not all competent engineers possess the ability to write a good preliminary report, particularly in the case of a small project.

The proper charge for such a report is generally from five to twenty cents per capita. Despite the violation of the code of ethics of the American Society of Engineers, involved members and non-members of this organization do offer free preliminary reports to municipalities; or, in order to avoid this violation, ask for ridiculously low fees for such work. Needless to say, it is always advisable to "look a gift horse in the mouth." Most municipalities are now wise enough to shy at the engineer who offers free service, or asks ridiculously low fees.

The reputable engineer can do himself some good by showing his report to his prospective clients, and requesting that they ask other applicants to do likewise. When proposals are submitted by competing engineers, public officials should request that the price made for a preliminary report should be accompanied by a

"sample" report from a similar project.

Following the submission of a preliminary report, there is generally a period of weeks, months, and occasionally years, before the municipality takes action thereon.

Granting that action is ultimately taken, the municipality adopts a resolution in favor of one of the systems of supply and distribution recommended in the preliminary report. If general obligation bonds are to be issued, an ordinance must be passed providing for an election. Again the writer calls attention to the desirability of having such an ordinance, however simple a document it may appear to be, approved by a legal specialist, before the election is held. If the ordinance is faulty, the election is null and void. A new election is often disastrous to the success of the project; it is always an expense. If the bond issue carries, the engineer breathes a prayer of thankfulness, and after being formally notified by the municipality, proceeds with the detail plans. If some other method of financing is used, the engineer generally proceeds with the detail plans when the municipality, by resolution, adopts some particular source of supply and distribution system, and, by resolution, authorizes the engineer to proceed. Occasionally, in such cases financial difficulties appear at this stage, delaying the project.

If revenue bonds are to be issued, it is important to note that they may be sold after the ordinance is passed; or they may be paid to the contractor as the construction work progresses. In the latter case, the contractor must dispose of the bonds himself, and make allowance in his bid for the estimated or actual discount on the bonds. In most cases he must secure and pay for an opinion on the legality of the bonds from some legal specialist. Ordinarily he does not sign the contract until he has this opinion. As has been stated elsewhere, this is an illogical procedure. It is unquestionably better for the municipality to retain a legal specialist at the start of the project, and pay for his services direct.

A detailed, step-by-step outline of the procedure under the special assessment method, or proceedings under a combination of the different methods of financing municipal water systems, which are too involved for these pages, would serve no useful purpose. In all such matters the engineer needs the guidance of proper legal counsel.

In designing a water system for a small community there are certain general observations and considerations which a public official or novitiate engineer, should keep in mind. The following suggestions may not be complete, they are not infallible, and they are subject to many exceptions, but they are useful as guideposts.

A municipality of less than 5000 population, unless favored by exceptional local circumstances, can seldom

finance, solely by means of revenue bonds, a complete system of supply and distribution.

A municipality of less than 2500 population can seldom honestly finance any other source of supply than that of wells solely by means of revenue bonds. On the other hand, there are certain sections in Illinois where well supplies are uncertain as to quality and quantity. In these sections financial problems far outweigh engineering problems.

A municipality of less than 2500 population is seldom justified in charging consumers less than two dollars per month and the municipality itself less than 50 dollars per year for fire plugs, where the major portion of the system has been financed by revenue bonds.

An elevated storage tank, as far away from the source of supply as possible and on a high point, is a sound investment; it equalizes pressures, provides storage for fire protection and, in places, makes for economical operation of the pumps.

The use of less than six inch mains should be discouraged. The cost of the six inch cast iron mains is seldom more than ten percent over the four inch mains and the capacity is twice as great.

The regulation of the Illinois Inspection Bureau should be followed as closely as is financially possible, in order that fire insurance rates may be as low as is possible. In arriving at the proper classification of a municipality for fire protection, the National Board of Fire Underwriters allots 1700 points to the water supply, 1500 points to the fire department, and the remaining 1800 points out of the allotted 5000, to various other factors affecting fire loss. It can be seen, therefore, how important the relation of the public water supply is to fire insurance rates.

Hydrants are cheaper than fire hose. Furthermore the friction loss in good hose is 10 pounds per 100 feet of hose. Consequently, 50 pounds at the hydrant will be reduced to an ineffectual trickle by the time it has passed through 500 feet of hose.

The problems encountered most frequently in the small municipality now having a water supply are generally of two broad classifications: those municipalities who have found their source of supply inadequate or unsatisfactory, and those who desire to purchase the property of the local privately owned water system.

The financial and engineering considerations involved in the former case are much the same as those involved in the case of a municipality without any water system, with this important exception: fair to excellent statistics on revenue and water consumption can be obtained. There is, therefore, little excuse for improperly financed and improperly engineered projects.

In the other case, the following observations are pertinent. Most water franchises provide that at stated intervals, generally at the expiration of five

or ten years, and (sometimes) at the expiration of the franchise, the municipality may take an option on the purchase of the property from the owner of the franchise. On such occasions the engineer is retained by the municipality to appraise and analyze the problem presented.

Such franchises provide that the value of the water company's property shall be arrived at by the board of appraisers. One of these shall be chosen by the municipality, one by the water company, and the third by the two already chosen. Each of the first two appraisers makes a separate appraisal; the third appraiser then serves, in effect, as an arbitrator; but the decision of such a board is generally binding on both the municipality and the water company. The expenses of the appraisal is generally borne equally by the water company and the municipality.

In addition to the appraisal of the property, the municipality should have a supplementary report made. This should analyze the present and future revenues and operating costs of the water system. It should also include construction estimates and suggestions for the improvement of the distribution system, if such improvement is needed.

If the valuation of the water company has been made in recent years by their engineers, or by the Commerce Commission, or both, the municipality may be able to reduce the cost of their appraisal by having a so-called check appraisal made. This will cost only from one third to one half the cost of a general appraisal. A check appraisal is made by assuming that the quantities arrived at by the previous appraiser are substantially correct. The important units, equipment, machinery, property, etc., are spot checked from reliable documents. While not as complete, reliable, or exhaustive as a complete appraisal, in many cases such an appraisal is necessary for preliminary negotiations.

The most feasible method, and in most cases the only method of financing the purchase of a private company by a municipality, is through the sale of water revenue bonds. As all but a few private water companies are "going" concerns, earning fair to good profits, it follows that revenue bonds are in their most favorable circumstances; and, in normal times, there is no difficulty in disposing of revenue bonds for such a project at satisfactory prices and interest rates.

The Services of Underwriters' Laboratories

By PROF. JOSEPH B. FINNEGAN

THE development of a profession of fire protection engineering has been a necessity in our complex industrial and social organization. The establishment of Underwriters' Laboratories was brought about because it was obvious that the fire protection engineer in the field could not accomplish what was expected of him unless he could look to a competent testing laboratory for information about devices and materials concerned with fire hazard and with the prevention of fire loss.

The Chicago World's Fair of 1893 was notable for many things, among them being the use of electrical equipment on a scale which was then without precedent. It was recognized that improperly installed electrical circuits and apparatus would have serious fire hazard, and the insurance underwriters brought to Chicago a young electrical engineer, William H. Merrill, who was assigned to inspection work in the interest of safety to life and property. He found that supervision of details of installation was not enough, and that laboratory tests were necessary. A single room on Monroe Street, above the quarters occupied by the salvage corps, was provided with equipment at a cost of about $350, and work was begun by Mr. Merrill with one helper and a clerk.

From this beginning, the story of the project is a recital of continual growth, not as a result of a deliberate policy of expansion, but to meet now one and then another request for service in some portion of the field of fire protection. A two-story brick building on East Twenty-first Street, earlier used as a school for boys, was acquired, and was outgrown in a few years. In 1904 a fireproof building was erected on the present site on East Ohio Street, and it has been extended progressively until it has a street frontage of 266 feet, a height of three to five stories, and floor area of about 100,000 square feet. The building is perhaps the best example in America of fire-resistive construction, provided with fire-resistive finish and equipment and with properly safeguarded machinery. In this build-

ing and its equipment the underwriters have adopted in their own property the measures they recommend in the property of others.

The staff at the Chicago principal office and testing station has increased from three to about two hundred and fifty. An office in New York, equipped for the conduct of examinations and tests of electrical devices under the same conditions as in Chicago, has its own engineering and office staff; another office in San Francisco is available for tests of most electrical devices. Engineers and inspectors for the Laboratories are permanently stationed in 72 cities in the United States and Canada.

The first work of the organization was confined to a relatively small number of electrical devices. The index of the Laboratories' latest edition of its List of Inspected Electrical Appliances contains reference to about 240 classes of devices and materials, the listings including many thousands of separate items. The index of the List of Inspected Fire Protection Appliances (mainly fire retarding materials and extinguishing equipment) contains the names of about 175 classes; the index of the List of Inspected Gas, Oil and Miscellaneous Appliances refers to about 200 classes. In fields not directly or solely concerned with fire protection the extent of the Laboratories' activities is suggested by the 89 classes included in the List of Appliances Inspected for Accident Hazard, the 39 classes in the List of Inspected Automotive Appliances, and the 53 classes in the List of Inspected Burglary Protection Appliances.

In the case of a large proportion of the devices which have been listed by Underwriters' Laboratories, the outward and visible sign by which the purchaser or the insurance inspector is informed of the favorable classification is the Laboratories' label. The presence of the label indicates not only that representative samples have been examined and tested, but also that, in cooperation with the manufacturer, a continuing system of inspection of the current commercial product is maintained.

The number of labels used in a year is expressed in terms of hundreds of millions. Listed devices and materials which do not lend themselves to label service are subject to other forms of countercheck known as re-ëxamination service, or special service.

The function of Underwriters' Laboratories is to develop the best available opinion regarding devices and materials involving fire hazard or fire protection. To arrive at this opinion it has been necessary to develop standards of many kinds, and to devise test equipment and test methods for which precedents were not available. While the Laboratories' plant is provided with the usual instruments employed in testing materials, it has much apparatus specially designed for its own purposes.

This equipment is used not only in connection with the investigation of devices to determine whether they comply with established standards, but to a considerable extent it is employed in research.

In testing electrical equipment, which was the first field which Underwriters' Laboratories entered, and which is still one of the most important activities, the intent is not to investigate the efficiency of the devices submitted. The concern of the Laboratories is with the fire hazard of electrical devices, and, in the case of electrical signaling equipment, its dependability. Laboratories' listings apply to snap switches and to interurban electric cars, to toy transformers and to welding machines, to lamp sockets and to player pianos, to soldering fluxes and to radios. The electrical list suggests a compendium of catalogues published by manufacturers of electrical equipment, except that large generators, motors and transformers are not included. Probably no part of the list is more important than the thirteen pages of small type that contain the references to inspected electric wires, or the fifty-one pages relating to switches.

In investigations of building materials, fire tests are made on partitions, walls, and floor assemblies in large, specially designed furnaces in which they are subjected to severe fire exposure while carrying the superimposed loads for which they are designed. Results of the tests are expressed in terms of time classifications. These classifications may be as short as ten minutes for certain partition finishes, or may be eight hours or more for some wall assemblies. Fire doors and shutters, and wired glass fire windows are tested in a similar way, a standard fire department hose stream being applied to the test sample from a distance of twenty feet immediately after the exposure to fire.

Typical labels on inspected devices, as furnished to the manufacturer.

The development of motion pictures with sound effects has made it necessary to provide many theaters with special interior surface finish to prevent reverberation. Investigation of these acoustic finishes by means of a furnace of novel design has been one of the interesting new developments at the Laboratories.

The protection of money, important papers, and especially valuable merchandise requires the use of fireproof safes. In investigating a safe, at least three samples are tested. One test involves prolonged exposure to fire. In the second test, another safe

is exposed to fire; then, while still hot it is picked up and dropped thirty feet upon a bed of broken bricks; afterwards it is subjected to fire exposure for a second time. The third safe is moved suddenly into a furnace which has been in operation until its interior is at high temperature; the intent is to determine whether the safe is capable of internal explosion which might blow its doors open. Listed safes are classified as providing one, two, or four-hour protection.

A standard automatic sprinkler system is by far the most effective fire extinguishing equipment that can be installed in a building. The automatic sprinkler must be well designed, and its manufacture requires good equipment and particularly careful machine-shop practice. The hydraulic department of the Laboratories makes elaborate tests on sprinklers, and on the various accessories of a sprinkler system, including pumps, various types of valves and alarm devices, pipe and fittings.

To the casual observer, the Laboratories' label appears most frequently on 2½ gallon fire extinguishers of the soda-acid type, and on one-quart carbon-tetrachloride extinguishers. These and many others, classified as non-freezing, carbon dioxide, foam, pail, pump, and miscellaneous, are examined for details of material and design and are subjected to tests to determine their extinguishing value. An interesting and rather difficult problem, which has been solved acceptably, was the building of fires of various size and intensity, using wood, cotton waste, excelsior, and flammable liquids. The effectiveness of any given extinguisher, handled by a skilled operator, is determined by actual experiment. Of course, in actual fires the skilled operator may not be available, but the method of testing provides a measure of the value of the devices themselves. In this, as in other cases, the work of the Laboratories in certifying to the quality of equipment must be supplemented by care and intelligence in the field by those who are responsible for installation and use.

Many materials and many processes to which we have become accustomed by daily observation have very considerable fire hazard. Almost every home uses gas for cooking. The gasoline which is in use or in storage at any given time in a modern city,—many hundreds of thousands of gallons of a most hazardous liquid,—has startling possibilities in causing and spreading fire. The dry-cleaning industry uses large quantities of liquids having properties similar to those of gasoline. Fuel oil is used in many industrial plants; the rapid increase in the use of oil-burners for domestic heating plants has brought the same combustible liquid into many dwellings. Within a few years the use of pyroxylin lacquers has brought about almost complete change in the finishing of fine wood and metal products. These lacquers

contain hazardous nitro-cellulose, dissolved in volatile combustible liquids. They are usually applied by spraying, which introduces fire hazard much greater than that of the older brushing processes. Acetylene, a gas with seriously hazardous properties, is used on a large scale in the welding and cutting of metals, and to some extent for lighting. Anesthetics of new character, involving some special fire hazards, are being used in hospitals. Nitro-cellulose films, in motion picture theaters, in hospitals and clinics, and in photographic studios, are exceedingly combustible, and produce poisonous gases in burning.

Superficially, it would appear to be the task of fire protection engineers, in the field and in the laboratory, to do everything possible to prevent the use of these dangerous materials. To a limited extent this has been accomplished. Perhaps the most notable example of the substitution of a relatively safe material for a much more hazardous one has been in the case of photographic film. Slow-burning film, listed by Underwriters' Laboratories is now used in many hospitals, and in motion picture projectors for home or educational use. Some dry-cleaning establishments now use liquids whose hazards are in a class with those of kerosene, instead of with those of gasoline. In general, however, it is quite out of the question to eliminate fire hazard by eliminating the use of combustible material. What would be thought of the sanity of an engineer who sought to reduce fire hazard in the home by advising the prohibition of gas ranges; who tried to reduce the amount of hazardous liquid in a city by outlawing the motor car; who tried to prevent the use of oxy-acetylene torches? The approach to these problems is from another direction. The nature and the degree of hazard are studied. So far as possible the equipment in which dangerous materials are stored or used is designed to reduce the hazard to a minimum. This can be done only with the cooperation of manufacturers, engineers, public and insurance authorities, and testing laboratories.

That portion of Underwriters' Laboratories work which deals with hazardous materials and equipment is especially important and interesting. In equipment designed for handling or storing gasoline, the Laboratories' list has eighteen classes. Acetylene equipment is listed under fifteen headings. The hazards of pyroxylin lacquers have been studied and recommendations have been made for safeguarding them. Tests have been made on matches and fumigants, on paper bags and sweeping compounds, on cleaning materials and on floor wax, and on a large number of other materials, solid, liquid, and gaseous. It is particularly the case with hazardous materials and appliances that the efforts of the Laboratories in developing and publishing the best available opinion has been fruitful of results.

The work of Underwriters' Labora-

tories has been made possible primarily through the support of fire insurance organizations. It has been aided materially by the National Board of Fire Underwriters. It could not have been accomplished without the intelligent cooperation of thousands of manufacturers of devices and materials who submitted them for Laboratories' tests, and who have had ample opportunities to confer and to advise in the preparation of Laboratories' standards.

The printed material issued by Underwriters' Laboratories includes lists of inspected appliances; cards reporting in summary form the results of tests; standards; formal reports; explanatory pamphlets of various kinds. Nowhere in these publications is there reference to the fact that for twenty-nine years there has been cooperation between the Laboratories and Armour Institute of Technology in the education of fire protection engineers. Since the establishment of the department of fire protection engineering at the Institute, the professional laboratory work of the junior and senior years has been carried on at Underwriters' Laboratories. This cooperation has been invaluable to the Institute. From the viewpoint of the Laboratories it has been, like the other activities of the organization, intended to help in the reduction of fire loss. In this, as in its other work, is apparent the application of the Laboratories' motto—"For service, not profit."

The Technical Student and His Library

By ELLEN STEELE

THE subject of the library and the engineering student is a very large order. Many articles have been written upon it, all with good advice and many of them very well handled. Instead of repeating much of this material when the subject has been threshed out from so many angles, perhaps we might consider what the engineering student might be as a reader.

Occasionally this remark is heard across the desk, "Well, I do not need to clear my record in here. I never use anything but a reference book, never took a book out of the library." It is not a statement to be proud of making. Those students have very likely wasted a lot of valuable time, and probably will never be anything but employees on a job. No student is so well informed in his own subject nor so well read in other subjects but what he can find many interesting books and magazines in the smallest collection. The day of the single textbook is past, and even when it was the back bone of the course the student who had ability, initiative or imagination wanted to know what others had done in his field. He had natural curiosity enough to do more or less original reading for himself. Besides texts and references that are the need of every student there are many biographies and volumes of general science offering inspiration and incentive to those who will read them. If the student has no other reason for reading he might be purely mercenary enough to feel he has paid for the privilege in his tuition, which he has.

Those who realize the value of books and plan the work of the courses place the library in the same position as the laboratory. It is a place for experiment and research, a place for recorded knowledge, on which the successive steps in the progress of all technical subjects depends. Part of the funds of the college are specifically applied to that department to equip it with tools (librarians, books, periodicals, society publications, catalogs, and bibliographies) to make it of easy access and real value to the student. The only failure in the scheme is that the library is ex-

pected to supply preparation for all departments, but seldom, if ever, has a budget equal to any laboratory. Those who direct the library and work in it can make every effort, but they can not make a reader out of one who has no interest. Students increase the resourcefulness of the librarians by their attitude; there has been much written on what the librarian can do to stimulate interest in reading but it is a two-sided subject.

The engineering student who limits his reading to his own particular subject is cheating himself. No matter how many books he may have access to, in his own home or elsewhere, in his college library there are many items worth his time and attention.

All this may sound as though the students of Armour Institute of Technology do not use the library, which would be a very wrong impression. Ninety percent of them use it for various reasons and there are many good readers, but many of the students with the highest grades never read at all, except when absolutely necessary. Good grades in assigned subjects are not all that make for scholarship, education or culture.

Mr. Bishop (librarian of the University of Michigan), in one of his talks on college reading, made a comment to this effect, "Few undergraduates or graduate students have the ability to meet men on terms of equality and intelligence." The most outstanding criticism made of engineers is the narrowness of their interests, other than those exactly pertaining to their line of work. It may be an age of specialization, and we may agree with the engineering student that he has little time for any reading, much less for serious reading in literature, philosophy, or history, but there are many opportunities to acquire knowledge of these fields in his general reading. There is no one who knows better than the librarian how many hours a year the students waste when they might be reading. There are many ways of combining the two fields and it is too bad to pass them by during the years when the mind most easily absorbs new ideas, the opinion is more pliable, and the memory most retentive.

When a student elects literature as his subject, he can not work in modern writers only with any success. He must know literature back through the ages to have any real understanding of the present work. He must study philosophy, history and religion to realize why and how the writers were influenced in their particular trends. Out of this he gains a fair knowledge of the development of the sciences. Why should not the engineering student use the same process to gain his knowledge of civilization, literature and general history? The student working in highway engineering might read many interesting works on the history of roads and bridges; we seldom have such a request. The history of road making goes hand in hand with the history of civilization.

The student will choose to write a theme on the present-day gas tax for road construction, but will never think of reading Jusserand's "English Wayfaring Life in the Middle Ages" with its accounts of the first taxes in the form of tolls collected by hermits along the main highways, where they busied themselves with the upkeep of the roads; also the accounts of riots because the public, then as now, objected to the increased taxes. He should read the life of John Metcalf, one of the three great English road engineers, born in 1717, blind from the time he was six, but nevertheless a successful surveyor and builder of roads. Bridges were of early origin in England, usually constructed under ecclesiastical authority. The first road bridge of stone was constructed by order of Matilda, wife of Henry I, because her life was endangered in crossing by ford. Samuel Smiles has referred to bridge chapels, where monks stood in the center of the spans to receive offerings used in the upkeep of the bridges. The same idea may be seen in modern bridge control, the uniform of the attendant being the only difference. One might follow the history of our own country in "Historic Highways of America," by Archer B. Hulbert, or read biographies of such men as James Geddes, a Latin and Greek scholar and well-known lawyer before he began his work on the Erie Canal; or of the Roeblings, Clemens, Hershel, or Thomas Cooper.

The student working in hydro-electric power plants can tell one all about the turbines, the capacity and the water discharges of the Panama Canal, but does not know how greatly interesting were the lives of the men who worked on it. Few know that many of the volumes from the private library of Colonel Harry Foote Hodges are among the books of the Armour Library.

Students take so for granted the work of the leading scientists and engineers, never knowing anything of their lives or how they happened to work along certain fields. Michael Farraday began work as a book-binder and studied from the books he was supposed to be binding. His employer, Riebau, told him, "Go ahead, read all you please. You will be no worse book-binder for knowing the insides as well as the outsides of books." So it was he happened on an article on electricity. William Sturgeon, inventor of the electro-magnet, worked for years as a shoemaker. There are those who ask what difference what these people did or were; all they want is the Wheatstone bridge experiment or something on Laplace's theory. It does seem, however, that the names of workers in scientific fields should be as well known to the engineering and scientific student as are the names of Ben Jonson, Beowulf, Geoffrey Chaucer and John Fletcher to the student of literature.

The students in chemistry know the names of leading references, Rich-

ter, Beilstein and Mellor, but they consider hours spent outside the laboratory as a waste of time; few of them read anything on the history of chemistry. Just as out of astrology grew astronomy, so was chemistry the result of alchemy, and alchemy was a mixture of religion, philosophy and science. It was perhaps as scientific, according to what the alchemist had to work with of tools and knowledge, as is our chemistry of the present day. The chemical engineering student would probably resent the fact that the dons of Oxford tried to dissuade Robert Boyle from the study of chemistry, saying it was not the study for a gentleman. One can not read the history of any period without knowing of its scientists and their works. The name of Leonardo de Vinci is usually connected with the painting of the "Mona Lisa," or the "Last Supper"; he is seldom thought of as an engineer and scientist, yet his work on the internal combustion engine and in experimental science is often mentioned by the writers of 12th and 13th century history. Georg Bauer, better known as Agricila, whose work in metallurgy and mineralogy formed the basis of many developments in modern engineering, is accessible in the very fine translation by President and Mrs. Hoover of his best known treatise, "De Re Metallica."

The original thesis as well as the translation is in the Armour Library. Certain early experiments in illumination are interestingly written of in the memoirs of Sir Humphrey Davy.

I might go on indefinitely in the naming of these people who played such a large part in the making of history, as well as forming the background of engineering and science. Source materials are being more and more respected, instead of the center of the stage being given to the "mechanics" of the subject. The engineering student will come to an appreciation of the fact that history is not "just a bunch of dates," or literature a "lot of silly poetry and plays that never did anyone any good."

Mark's "Handbook," a five place logarithm table and Watson's "Practical Physics" may be very necessary and highly useful reference equipment, but they will never make a "gentleman and a scholar."

Developments in the Field of Synthetic Lubrication

By EDMOND P. LOMASNEY

LUBRICATING oil as used today is prepared from mineral oil, which occurs in large quantities deep under the crust of the earth. This mineral oil or crude petroleum is mined, refined, and put on the market for commercial use. The consumer buys the oil according to its classification and uses it until it has no further value as a lubricant.

Lubricating oils are classified according to their physical properties, and should be used accordingly. An oil for use in an ice machine is entirely different from that for a hot running gas engine. The oil used in the gas engine must have a low temperature coefficient, while the oil used in the ice machine must have a low pour point. An oil having a low temperature coefficient is one that has a small change in viscosity with temperature, while an oil having a low pour point is one that has the ability to flow at low temperatures. Oils having low temperature coefficients are of the "Pennsylvania" type and those of low pour point are of the Gulf Coastal or "Texas" type. Pennsylvania oils are said to be "paraffinic" in nature, and Gulf Coastal oils are said to be "naphthenic" in nature.

Lubricating oils are generally understood to be composed of a mixture of high molecular weight hydrocarbon molecules. Physical characteristics can be traced back to the molecular structure. As previously mentioned, oils of "paraffinic" nature possess the important physical property of having low temperature coefficients, due to the chain-like structure of the majority of the molecules, while oils "naphthenic" in nature possess the physical property of having low pour points, due to the ring-like structure of the molecules.

Since most industrial machinery demands oil of low temperature coefficient, this oil is considered as being higher in quality than the high temperature coefficient, low pour point, naphthenic oil. Paraffinic oils contain this valuable physical property along with other inseparable properties such as abnormally low vapor pressure for a given viscosity, low density and low sludging tendencies. This is the chief

reason why Pennsylvania oils are in more demand than the Texas or Gulf Coastal oils.

The viscosity temperature coefficient is an awkward term to handle, so Dean and Davis devised the term "viscosity index," by which an oil can be graded according to its temperature coefficient value. An oil of paraffinic base, Pennsylvania, has a viscosity index of about 100, while that of naphthenic base, Gulf Coastal oil, has a viscosity index of about 0. Any thing that has a viscosity index of over 100 is better than Pennsylvania and has a remarkably low temperature coefficient, and anything having a viscosity index of less than 0 is not as good as Gulf Coastal stock and has a very high temperature coefficient. The viscosity index of each oil was calculated for a viscosity of 85 at 210°F.

Since paraffinic oil is composed of a mixture of hydrocarbon molecules, some of which are desirable and the others undesirable, we can readily see that this oil as nature furnishes it, is not the ideal lubricating oil. The desirable lubricating oil would be one that contained nothing but desirables. By the desirable component we mean that part of the oil that furnishes the physical property of low temperature coefficient. Such an oil as a perfect lubricant does not occur in nature, therefore it must be made by man. Man's tool in the manufacturing of this lubricant is synthetic chemistry, with which he can fashion any oils that are suitable for his purpose.

Synthetic chemistry in the petroleum industry is still in its infancy, and it is only in the last ten years that man has made much progress along this line. The first important article pertaining to the use of synthetic lubricants in industry was published in June, 1931, in *Industrial and Chemical Engineering*. The authors of this article, F. W. Sullivan, Jr., V. Voorhees, A. W. Neeley, and R. V. Shankland, are important in the field of synthetic lubricant production. They mention the fact, in their paper, "Synthetic Lubricating Oils," that the Standard Oil Company of Indiana is already manufacturing synthetic lubricating oils on a commercial basis. This is a positive indication that soon synthetic lubricants will play an important part in industry.

As has been stated previously, man can make an oil to suit any purpose with the use of synthetic chemistry. This is possible due to the fact that man can start with a highly unsaturated gasoline, and end with a lubricating oil.

There are various factors in the manufacture of synthetic lubricants that enter into the making up of the final product. For instance, time, temperature, and character of charging stock must be considered. However, the most important factor in the manufacture of synthetic oil is the aluminum chloride treatment. This compound is responsible for all important synthetic petroleum products. There are other materials such as

boron flouride, ferric chloride, etc., which can be substituted in place of anhydrous aluminum chloride, but they do not perform the task as well. In fact, under the conditions used, all other catalytic materials are much inferior to anhydrous aluminum chloride, both because of price and effectiveness in treatment.

Synthetic lubricants are formed by the catalytic action of anhydrous aluminum chloride or unsaturated organic compounds. The unsaturated organic compounds in this case are unsaturated hydro-carbon molecules, commonly called olefines. These olefines are polymerized when they come in contact with anhydrous aluminum chloride; that is, they combine and form heavier and more complicated molecules, which combine with yet other molecules, and so we finally end with a liquid that has all the properties of the natural lubricating oil composed of a mixture of heavy molecular weight hydro-carbon molecules. To clarify this the necessary steps in the manufacture of synthetic lubricating oil will be followed through.

The olefine to be treated is charged into a device with some sort of mechanical agitation, a definite amount of anhydrous aluminum chloride is put into the charging stock and stirred for a definite period of time, at a definite temperature. After this time has lapsed, and all the conditions have been faithfully lived up to, the final product is removed from the stirring apparatus, separated from the aluminum chloride sludge, and purified. The stock charged into the treater is

Effect of Wax Concentration of Synthetic Oil Stock Cracked and the Distillate Polymerized

Stock Dist.	Boiling Range of Dist. Polymerized °F	(°C)	Yield Wt. % of Dist.	Vis. of Product 100°F (37.8°C)	210°F (98.9°C)	Vis. Index	Grav. °A.P.I.	Cold Test Solid °F	(°C)
(low cold test press drip)	300-500	(149-260)	50.5	1500	86	41.1	23.6	0	(-17.8)
40% Wax	300-500	(149-260)	46.5	1030	87	90.0	28.5	–	
65%	Init.-530	(Init.-277)	42.2	804	77	90.5	29.4	-20	(-28.9)
70%	300-500	(149-260)	50.0	835	84	103.5	30.8	-36	(-37.8)
75%	Init.-526	(Init.-274)	44.2	840	83	99.0	30.9	-20	(-28.9)
85%	Init.-496	(Init.-258)	51.0	780	83	107.5	31.8	-25	(-31.6)
95%	Init.-590	(Init.-310)	64.1	675	86	123.0	34.0	-20	(-28.9)

Each viscosity index was calculated directly from the viscosities given.

Effect of Boiling Range of Cracked Distillate from Refined Paraffin Wax on the Synthetic Oil

Distillate Fraction Polymerized °F	(°C)	Viscosity of Product (Saybolt) 100°F (37.8°C)	210°F (98.9°C)	Viscosity Index	Yield Wt. % of Distillate	Gravity °A.P.I.	Cold Test Solid °F	(°C)
Init.-200	(Init.-93.9)	1083	88	87.2	52.0	31.5	-25	(-31.6)
200-310	(93.3-154.5)	926	95	96.1	52.0	31.3	-25	(-31.6)
310-420	(154.5-215.5)	637	84	124.4	69.0	34.4	-36	(-37.8)
420-510	(215.5-265.5)	1565	157	123.5	67.5	33.7	-12	(-24.4)
Init.-428	(Init.-220)	797	85	109.3	45.0	33.1	-15	(-26.1)

not viscous material, while that obtained and recovered as the final product is very viscous.

The earliest tabulated data as to the action of anhydrous aluminum chloride on hydro-carbons were those of Ador and Riliet. This work was closely followed by the work of Jacobsen, and Anschütz and Immerdorff. Friedel and Craft now made their first appearance, by publishing their first work. While Craft was a student under Friedel in the Sorbonne in Paris in 1877, the reaction which bears their names was discovered. In contradiction to Anschütz and Immerdorff, Friedel and Crafts stated that the reaction occurring was much more complex than a simple migration of alkyl groups.

A good deal of time now elapsed before more chemists investigated the aluminum chloride catalytic field. However, when investigation did begin, it began with a rush. The works of Browlee, Engler and Roulate, Gangloff and Henderson, Humphrey, Leamon, Nash, Stanley and Bowen, and numerous others were published. Recently, reviews on the manufacture of lubricating oils (including synthetic oils) have been written by Krauch, Clarke Lee, Nash, and Stanley. The work published by F. Sullivan, V. Voorhees, A. Neeley, and R. Shankland, however, is the most complete; it gives a clear story of the manufacturing of synthetic oils with aluminum chloride as a catalyst.

To get effective polymerization the aluminum chloride used in treating the charging stock must be in the anhydrous state. Previous investigators have tried plain crystalline aluminum chloride and found to their surprise that they got no reaction with organic hydro-carbons. It was not long before it became generally understood that the anhydrous aluminum chloride and not the ordinary aluminum chloride was the catalyst. Until the twentieth century this was the common source of error with all investigators. The chemists also made the mistake of not making a thorough investigation of the commercial possibilities of the subject.

The anhydrous aluminum chloride used in the manufacture of synthetic lubricants must be kept in intimate contact with the crude charging stock for a long period of time. Intimate contact is obtained by stirring the aluminum chloride, crude stock mixture in the treating apparatus.

The experimental apparatus used by Sullivan, Voorhees, Neeley, and Shankland consisted of a six liter cylindrical autoclave placed in a vertical position and provided with an agitator, a thermometer well, and a pressure gauge. Small scale experiments were made in four gallon steel cylinders mounted on trunnions like a churn and heated by an internal steam coil.

In order to obviate the small differences due to variation in polymerizing conditions, Sullivan, Voorhees, Neeley, and Shankland followed a de-

finite standard procedure as closely as possible. The following treatment is an illustration of their procedure. A solution of 420 gms. amylene in three liters naphtha, rendered inert by previous aluminum chloride treatment, was agitated with 75 gms. aluminum chloride for eight hours at 135° F. (57.2°C). At the end of this time the product was allowed to settle, sludge was separated, and the supernatant solution of oil, after being washed with caustic soda solution and water until traces of acid had disappeared, was reduced with fire and steam to the desired viscosity.

Paraffinic oils are of the highest quality and since there is a direct relationship between the character of the initial stock and that of the final product, it can be assumed that if we treat an olefine distillate of paraffinic origin, the final product will be an oil of the Pennsylvania type. This is true, and if the charging stock is cracked wax distillate, of paraffin nature, the final product will be a very good grade of lubricating oil. The grade of the final lubricant also depends slightly on the boiling point range of the charged stock. A set of tables are taken from the article, "Synthetic Lubricating Oils," which illustrate the effect of the boiling point range of distillate on the final product. An oil of naphthenic base is generally wax free, and it is only the rare exceptional Gulf Coastal cracked distillate that will yield a high quality final product.

When synthetic lubricants are manufactured, the final product or the lubricant depends much on the three variables, time, temperature of treatment, and concentration of aluminum chloride. The duration of treatment is one of the main factors that determine the yield of final product; the longer the time of treatment the

Effect of Time of Polymerization on Yield of Oil Stock—Cracked Distillate from 85% Wax

Time Hrs.	Temp. °F	Viscosity of Product (Saybolt) 100°F (37.8°C)	210°F (98.9°C)	Yield Wt. % of Dist.	Grav. °A.P.I.	Cold Test °F	(°C)
4	210	530	70	66.0	31.9	5	(-15.0)
4	210	1791	137	36.0	30.8	-25	(-31.6)
9	210		83	66.0	32.0	-5	(-20.6)
9	210		137	43.4	–	–	
9	210	2069	154	39.0	31.0	-25	(-31.6)
18	210	623	75	68.5	31.7	–	
18	210	2063	152	42.0	30.8	-25	(-31.6)

Effect of Temperature of Polymerization on Yield of Oil Stock—Cracked Distillate from 85% Wax

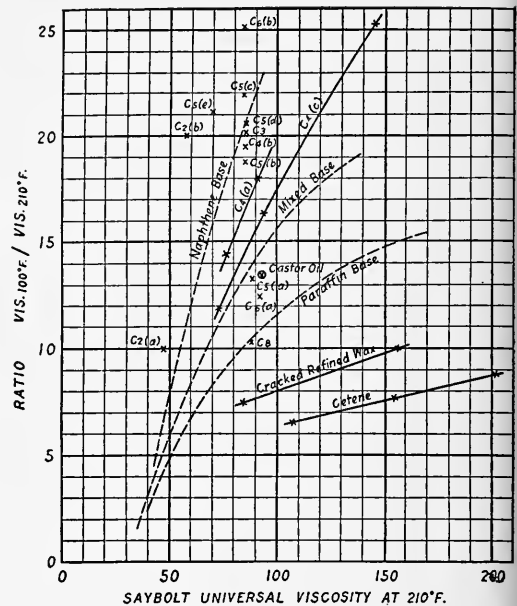
Temp. °F	Time Hrs.	Viscosity of Oil 100°F (37.8°C)	210°F (98.9°C)	Yield Wt. % of Dist.	Grav. °A.P.I.	Cold Test Solid °F	(°C)
Room	114	1273	110	51.5	30.5	0	(-17.8)
Room	114	2776	155	42.5	30.5	-20	(-28.9)
150	18	1172	106	56.0	31.0	-15	(-26.1)
150	18	2311	158	41.0	30.3	-25	(-31.6)
210	18	623	75	68.5	31.7	0	(-17.8)
210	18	2063	152	42.0	30.8	-25	(-31.6)
250	18	730	82	65.3	32.0	-5	(-20.6)
250	18	–	147	42.5	–	-10	(-23.3)
300	18	425	63	64.5	33.4	5	(-15.0)
300	18	1732	138	35.0	30.4	-15	(-26.1)

Effect of Aluminum Chloride Concentration on Yield of Oil Stock—Cracked Distillate from 85% Wax

%AlCl₃ Based on Charge	Polymerizing Conditions Time Hrs.	Temp. °F	Viscosity of Oil Saybolt 100°F (37.8°C)	210°F (98.9°C)	Yield Wt. % of Distillate	Gravity °A.P.I.	Cold Test Solid °F	(°C)
1.7	18	175-200	775	83	48.5	30.3	-15	(-26.1)
3.4	18	175-200	730	82	65.3	32.0	-15	(-20.6)
5.1	18	175-200	765	85	60.0	31.9	-12	(-24.4)

higher the quality and the better the color of the final product. Aluminum chloride concentration affects the final product in a number of different ways. The quality, yield, and color of final product are all partly determined by aluminum chloride concentration. The included tables show the effect of these three variables on the product.

The following statements and included graph were taken from the article, "Synthetic Lubricating Oil", previously referred to. The accompanying chart illustrates graphically the variation of viscosity with temperature of a number of synthetic oils in comparison with naturally occurring American oils. The ratio of the Saybolt viscosity at 100°F. to that of 210°F. is plotted against the viscosity at 210°F. (98.9°C). Where more than one point is given for the same type of oil, e.g., synthetic oil from butene-2 it signifies that the oil was reduced to higher viscosity determined repeatedly. The interesting fact is brought to light that the points thus determined for a synthetic oil fall on a straight line, whereas the lubricating fractions from natural oils give points which fall on a curve. The significance of this is not fully understood, but it may indicate that the synthetic oils are homogeneous in their chemical composition, that is, contain the same type of hydrocarbons throughout the distillation range, whereas the natural oils may contain more paraffinic hydrocarbons in the heavy end than in the light end.



Viscosity Characteristics of Synthetic Oils

$C_2(a)$—Ethylene (Nash)	$C_5(b)$—Pentene-2
$C_2(b)$—Ethylene (Nash)	$C_5(c)$—3-Methylbutene-1
C_3 —Propylene	$C_5(d)$—2-Methylbutene-1
$C_4(a)$—Butene-1	$C_5(e)$—Trimethylethylene
$C_4(b)$—Butene-2	$C_6(a)$—Hexene-1
$C_4(c)$—Isobutylene	$C_6(b)$—Cyclohexene
$C_5(a)$—Pentene-1	C_8 —Octene-1

The two heaviest distillate oils prepared by Nash and his co-workers are plotted for comparison. The viscosities were transposed to Saybolt and values at 100°F. and 210°F. obtained from Herschel diagram. It is seen that these oils are distinctly inferior to natural American oils from the standpoint of viscosity temperature characteristics, a fact which was recognized by Nash.

The viscosity of castor oil is also plotted, using data from the International Critical Tables. It is seen to be somewhat better than mixed-base oils with respect to vicosity-temperature coefficient, although quite inferior to the natural paraffinic oils and the better synthetic oils.

The synthetic oil manufactured by Sullivan, Voorhees, Neeley, and Shankland was polymerized with solid anhydrous aluminum chloride.

The petroleum industry is going to depend more and more on the manufacturing of synthetic lubricating oils, due to the fact that they are much superior to the natural oils.

As a conclusion the following generalized statements pertaining to the treatment and manufacture of synthetic lubricating oils can be made.

Charging stock. Keeping the time, temperature and percent aluminum chloride constant, it is possible to determine what effective relationship, if any, the charging stock had to the final product. The degree of unsaturation of the charging stock determines the yield of the final product. The nature of the charging stock used and the conditions of polymerization also determine yield. The physical characteristics of the charging stock have a direct relationship to the physical characteristics of the final product. If a very unsaturated material of paraffinic nature is used as charging stock, the conditions for polymerization being of the best, the final product will be an excellent yield of high quality lubricating oil.

Temperature. Keeping the other three variables constant, the effect of temperature on the treat can be noted. The higher the temperature, the better the quality of final product, but the lower the yield and the poorer the color. The poorer color signifies that the oil is getting darker. The temperature also has a direct bearing on the time. If the temperature is high, the time of treatment is shorter.

Time. The time has much the same effect on the treatment of the stock as the temperature. However, the time also has an important bearing on the yield; the shorter the time, the smaller the yield. As mentioned in temperature, the time of the treat varies inversely with the temperature.

$AlCl_3$ percent. The weight percent of aluminum chloride charged into the apparatus with the charging stock is of utmost importance. If the percent aluminum chloride is low, the time of treat must be long and the temperature low or the yield will be very poor. Of course, the quality of charging stock also has a direct bearing on the yield. However, in synthetic lubricating oil work it is advisable not to use less than two percent by weight of aluminum chloride. F. Sullivan, V. Voorhees, A. Neeley, and R. Shankland found it advisable to use three percent by weight of anhydrous aluminum chloride.

THE TECHNICAL BOOKSHELF

REVIEW OF NEW BOOKS OF ENGINEERING AND SCIENCE

New Conceptions of Matter

By Charles G. Darwin

(Macmillan. $3.00)

UNDER the powerful analysis of Twentieth Century physics, matter assumes new and startling aspects. As we perceive it in the ordinary experiences of life, we are as far from its ultimate nature as our perception of middle "C" on the piano is from the 256 vibrations of the string that produced it. We are conscious of sound, as such, but not of anything vibrating.

The quantum theory and the structure of the atom as a nucleus surrounded by whirling electrons; these are at the core of the new conception. Just what they mean is an involved story. Not only involved, but exceedingly unsimilar to anything that occurs commonly in our everyday lives. We can form ideas of kinetic energy from visualizing motion of an automobile, for example, and by thinking of the braking effort required to stop it; but what are we to do when the subject of the case is the wave aspect of the electron as distinct from the particle aspect?

Wherever possible Prof. Darwin illustrates his subjects by analogy with familiar examples from elementary physics. Events of nature are used also, especially that old favorite of poets and physicists—the waves of the ocean.

The huge amount of experimental fact on which the quantum theory has been based imposes a difficult problem of continuity. ". . . the so and so theory, which we shall take up later," appears on every other page. He does take it up later, but meanwhile the reader may have lost some of the picture.

The actual mechanics of the experiments are explained in detail minus the mathematics, which satisfies the reader in his curiosity about just how conclusions are reached. This information lifts the physicist and physics from the level of magic and places it on a less glamorous plane of mathematical logic. That elusive electron is only made to perform in the desired manner after its action is carefully anticipated by the rigorous logic of mathematics.

Prof. Darwin does not make the new physics a basis for any metaphysical deductions. He presents no relation between God and the atom; he has no Divine interests behind the Quantum theory. He says in his introduction that he has no ability for this work. That kind of modesty is a

delight, but the fact of the case is that he is perfectly capable, since one man's guess is as good as another's.

The author only hopes. "I shall count myself as having succeeded, if at, the end of the book, any surviving reader will speak no longer of the mysteries of life, but the naturalness of Nature."

Telephone Theory and Practice

By Kempster B. Miller

(McGraw-Hill. $5.00)

THIS is the first book of a three-volume series on telephone work by an author who has had wide experience in this line. The intention is to aid in co-ordinating the various phases of a great industry that is dealt with by the great number of specialized periodicals and reports of telephone laboratories and manufacturers.

Part One roughly traces the history of exchange of intelligence by various modes,—from the grunts of cavemen to the clicks of the nineteenth century telegraph—traces the attempts and failures of oral communication at a distance, and then plunges into the dramatic discovery of the telephone principle by Professor Alexander Graham Bell, and the heavy stream of development following it. The years up to the present pass in quick review and unfold the complex spectacle of the modern telephone system.

The second part of the book lays the foundational theory necessary for a thorough understanding of the practical problems encountered in the operation of this intricate system. A wealth of theory about every aspect of the industry is covered. From the discussion of sound, physically and physiologically, to vacuum tube operation, all pertinent matter is presented in great detail. The subject of acoustics, not usually given much attention, is specially emphasized as underlying many important practical problems, and the various aspects are thoroughly probed.

The last part deals with the elements of telephone apparatus now in use and is complete enough to be used as a working handbook by the various workers in telephony.

The volume is profusely illustrated and contains a large number of diagrams and graphs from the Bell Telephone and other laboratories.

A History of Architecture on the Comparative Method

By Sir Bannister F. Fletcher

(Charles Scribner's Sons. $12.00)

THIS recent addition to the Armour Library is a work known to students of architectural history throughout the world. The text, the ninth edition, has been corrected in accordance with the latest investigations, and nearly five hundred additional photographs have been included. Modern English and

American architecture have been treated at greater length in order to bring the History of Architecture down to the present day.

The general plan of this book is the division of the discussion of each style into four parts. The first part shows the influences which have given rise to the style. The second part gives the architectural character. The third part is a description of outstanding examples, and the fourth a comparative analysis of these examples. In scope, the work is immense, covering practically every style that has existed in the world from prehistoric architecture to the present day, illustrating each by sketches and photographs of examples.

It would seem that this book would be of value only to the architect or architectural student. This, however, is not true, for a work of this magnitude is not nearly so limited in appeal. It has been said that one of the best ways to understand any historic race is through its architecture and allied arts. Architecture is the living, physical expression of a race. Its creeds, character, and ideals being carved into the stone and set forth where all who can may read them. To give, besides technical information, this humanistic acquaintance with the great architectural developments of the past is one of the functions of this book, and it would be worth the while of anyone, even an engineer, at least to glance through this monumental work.

Applied Gyrodynamics

By Ervin S. Ferry

(John Wiley and Sons. $4.00)

THE gyroscope has long been of interest to man. To the layman, it has been an inexplicable marvel. To the physicist, it presented an involved science known as gyrodynamics. To the engineer, it has opened up the field of applied gyrodynamics. Recent times have been marked by the advent of many devices employing the principle of the gyroscope. Consequently, this book should be of especial interest to the engineer.

Beginning with a brief summary of dynamics, the theory of gyrodynamics is developed. This theory is too involved for the casual reader, but for one having a good foundation in mechanics, it should be comprehensible. Various applications of gyrodynamic principles are then introduced, accompanied by appropriate theoretical and descriptive material.

In the list of applications we find many interesting devices, such as an instrument for measuring the crookedness of a well casing; the Sperry airplane horizon, an instrument of great importance in blind flying; the Sperry automatic airplane pilot, a device which controls both horizontal and vertical directions of an airplane; the Sperry-Carter track recorder, which calibrates differences in the elevation of the two rails of a railroad track; the gun-fire directorscope, which fires a gun on shipboard at an

assigned angle with the horizon; the automatic steering gear for torpedoes; anti-roll devices for ships, and various types of navigation compasses.

The Witchert Truss

By D. B. Steinman
(D. Van Nostrand Co. $2.75)

THE author describes the Witchert Truss as: "a truss of over two or more spans in which the members over each intermediate pier forms a quadrilateral." The quadrilateral is hinged at each of its four points. Its application to bridge design is a recognized means of eliminating several of the worst difficulties in bridge construction.

This type truss is not affected by temperature changes or pier settlement in any way that results in large indeterminable stresses in its members. A pier may sink a foot after it is put in place and the stresses will not be varied over one or two percent. Variations in temperature have only about one-tenth the effect present in a rigid construction of the conventional design. The hinged quadrilaterals change their shapes to accommodate the conditions imposed upon them, giving a geometrical readjustment rather than overstressing the members. The author claims a greater economy of time and money in both designing and constructing this bridge over any of the conventional types.

A complete analysis of the mathematics of designing the Witchert Truss, with much empirical matter collected from experience gained from construction of many of these bridges, is given. There are also many excellent drawings included of the important details, which are perfectly complete.

Planning for Good Acoustics

By Hope Bagenal and Alexander Wood
(E. P. Dutton & Co. $6.75)

THE authors of "Planning for Good Acoustics" start their work with an elementary discussion of the nature of sound and its propagation. Following this is a review of the principles of reverberation and the results of experiments on this phenomenon. The period of reverberation is the controlling element in the acoustical problem; if it is too long, syllables and words are blurred into one another; if too short, music lacks volume and fullness. The amount of reverberation present is determined by the absorption of the surfaces upon which the sound is cast—walls, ceilings, chairs, audience, and drapes. Tables are given in which can be found proper constants to be used in the mathematical expression for the reverberation period for every possible kind of absorbent to be found in halls. It is pointed out that, in general, women absorb more sound than men.

The principles of sound reflection are next presented with an explanation of a method of planning which eliminates "dead spaces."

The Handbook of Oil Burning

By Harry F. Tapp

(American Oil Burner Association. $3.00)

OIL burning is one recognized solution of the problems of the combustion and heat power engineer. Like any of the innumerable possibilities present for the generation of heat, economic and convenience factors determine its application.

"The Handbook of Oil Burning" is compiled to give the facts concerning this method of fuel combustion and its uses. Various designs of burners which have been developed are included along with complete tables, graphs, drawings, etc.

Those fundamentals of engineering work related to oil combustion are presented in chapters on flue gas analysis, oil properties (physical and chemical), heat transfer theory and boiler design. There are three chapters on commercial phases: sales and service, ordinances, insurance codes, testing, accounting and business law.

Its text matter is readable to a degree that is uncommon in the large mechanical engineering handbooks, due to the necessity of their being brief. The more detailed descriptive matter found in this handbook gives it added value to the user.

Colour Index

By F. M. Rowe, Editor

(The Society of Dyers and Colourists. $35.00)

THE Colour Index of the Society of Dyers and Colourists has been brought up to date with a new 1932 supplement to the full edition of 1929, both of which are now to be found in the Armour Library. The new supplement contains much valuable current matter and costs $4.00.

The Index is a classification of over one thousand dyes according to color, fastness, scientific name, preparation, properties, and application. The notes on preparation, according to the Editor, F. M. Rowe, are not to be taken as complete, but only as an outline that should be of assistance to the chemist. References for more complete information are given.

There is a blank space left at the side of each page for notes. At the back of the volume is a patent index, giving the names of the patentees and the date of issuance.

Air Conditioning for Comfort

By Samuel R. Lewis

(Engineering Publications, Inc. $2.00)

THIS volume has been issued in response to the almost universal interest in the subject of air conditioning, as it may be applied to the home and to smaller stores, offices, etc.

The book treats of theory and practice. It takes the reader logically through the fundamental data required in the designing of a system of air conditioning; shows the application of the formulas developed to the necessary calculations; and finally proceeds to the actual calculations required for two residences and a restaurant installation.

It is indicative of the practical view-

point adopted by the author that he has insisted throughout the book on this thought: "Heating systems are considered in this book along with cooling systems," he says in his preface, "because of the very close relation between the two, and because it appears inevitable that the best cooling systems of the future will be those, the designing of which was borne in mind when the heating system, with which it co-ordinates, was designed."

Earth Features and Their Meaning

By William Herbert Hobbs
(Macmillan. $4.25)

THE American reader possesses an incomparable interest for the remarkable. Earth features are well adapted to the satisfying of this trait of character, and an increase in leisure time and the development of transportation facilities have made this source of interesting realities available to him. A full appreciation of these marvels requires that the observer be versed in nature's method of revealing the past. The complexity of this science of earth history prohibits the average man from fully understanding it and often discourages him from obtaining a general knowledge of the subject.

This book is written so that it may be understood by the general reader. Consequently it is not of the usual text-book type of composition. Information is presented in a non-technical language augmented in clarity by means of a large number of illustrations.

Many interesting topics are discussed. It is shown that the general shape of the earth is tending toward that of a tetrahedron. The familiar hypothesis, which assumes that the earth has a liquid core, is shown to be a fallacy. A certain fact indicates that the core is twice as rigid as tool steel. Volcanoes, earthquakes, glaciers, rivers, lakes, mountains, and the atmospheric envelope are other subjects which receive their due share of attention in the book.

THE ARMOUR ENGINEER

Student Technical Publication of
Armour Institute of Technology

MEMBER OF NATIONAL SCHOLASTIC PRESS ASSOCIATION

VOLUME XXIV | NOVEMBER, 1932 | NUMBER 1

The Technical Executive

MANY brilliant, technically-trained men fail to attain executive rank because they concentrate so exclusively on engineering and similar problems that they neglect the study of the human equation.

Mr. C. E. Groesbeck, graduate engineer and prominent public utilities executive, has stated: ". . . The men called to leadership in business and finance must have far more than technical equipment. They must have an appreciation of the springs of action of men and the power to direct and inspire them. The relations and interactions of men are a thousand times more complex than those of materials."

When a position of monumental importance is to be filled, what qualities do boards of directors look for? The first test they apply to a man is, Has he the necessary ability? The second is, Does he know how to inspire loyalty and to handle men successfully? To fill these specifications, a man must measure up to Mr. Groesbeck's requirements.

Man's Metal Supply

UNTIL about twenty-five years ago, the world looked to the engineer to point out new paths for technical progress. Again, in a very few years, will the engineer be called upon; this time his assistance will be be required for the repleting of the world's supply of metals. Professor Theodore J. Hoover, Dean of the Stanford School of Engineering, believes that a dearth of metals will come upon the world, first probably becoming apparent with gold and tin. The first evidence of such a lack will appear within a century, he believes. Dean Hoover further declared that the world was using its supply of minerals and metals at an annual rate of 1,000,000,000 tons.

In the prevention of such a scarcity the engineer can, and probably will, play an important part. Two courses lay open to him. On one hand he can seek substitutes; huge possibilities lie in unused fields.

An alternative to the above is the future discovery of the immense stores of metal that lie in fields which, until the present time, have not seemed promising to the surveyor and the mining engineer.

The engineer, while solving this question, must work hand-in-hand with the economist and psychologist in order to develop these things in such a way that their benefit will be obtained without causing economic disorder.

THE GUEST EDITORIAL

The New Engineer

THE Board of Trustees wishes to congratulate THE ARMOUR ENGINEER on the splendid new publication which is introduced with this issue.

It is significant that this step toward the development of a greater school publication takes place at a time when the entire school is mobilizing to move forward into a position of broader usefulness in all of its functions. Through the instrumentality of the Armour Development Plan, it is hoped that Armour Institute of Technology will become a more effective agency, not only in supplying graduate engineers for industry and for professional engineering and architectural service here in the middle west, but also in bringing about a wider and clearer understanding of the importance of engineering in modern life.

By bringing to its readers a compendium of the news of engineering books, men, and events, THE ARMOUR ENGINEER will occupy a most useful and important position in the new scene.

—JAMES D. CUNNINGHAM,
Chairman of the Board of Trustees
of Armour Institute of Technology.

THE COLLEGE CHRONICLE

NEWS OF THE HONORARY GROUPS AND DEPARTMENTAL SOCIETIES

Tau Beta Pi

THE national all-engineering honorary fraternity is preparing for a year of exceptional activity and development. At the recent national convention in Washington, D. C., to which Pres. Davies went as delegate, a new chapter was taken into membership, at Marquette University, Milwaukee. Illinois Beta chapter, Armour, will install this new group very soon.

The chapter has elected, and wishes to announce the following new pledges:

Paul A. Carlstone, M.E., '33.
Norman E. Colburn, C.E., '34.
Raymond J. Dufour, M.E., '33.
Bradford Larson, F.P.E., '33.
William W. Lange, E.E., '33.
Bernhard H. E. Loesche, C. E., '33.
Stephen A. Vanderpoorten, F.P.E., '33.
Donald G. Wilson, E.E., '33.

Eta Kappa Nu

ETA KAPPA NU, honorary electrical engineering fraternity, will announce the winners in the annual essay contest in the near future. The main purpose of the contest is to stimulate the sophomore students to probe a bit deeper into some electrical engineering subject and give an interesting account in the form of a several thousand word thesis.

Many new ideas are certain to be presented by several of the new pledges.

Pi Tau Sigma

THE honorary mechanical engineering fraternity elected new officers to serve during the present year. The new leaders are: R. J. Dufour, president; H. J. Monger, vice-president; J. Moravec, recording sec'y; P. A. Carlstone, corr. sec'y; N. C. Penfold, treasurer; W. C. Buehne, librarian.

The national convention of Pi Tau Sigma will be held Nov. 18, 19, at University of Illinois. President Dufour will represent the chapter.

The scholastic leading man of the (freshman) mechanical engineering class is, each year, presented with a Kent's Handbook by the fraternity.

Salamander

THE honorary fire protection engineering fraternity elected officers for the 1932-33 school year at a business meeting in May. The present officers are C. N. Clanton, President; J. T. Sorensen, Vice-President; B. Larson, Secretary-Treasurer.

Salamander pledged the following men at a meeting held in the rooms on Oct. 3:

H. J. Bannasch, '33
C. A. Cunningham, '34
S. A. Vanderpoorten, '33

As pledges these men are preparing theses on some phase of fire protection work. The two seniors are combining on an analysis of the fire protection facilities at "A Century of Progress."

Chi Epsilon

ON May 20 the following men were initiated into the local chapter at a smoker held in the Triangle Fraternity House:

B. H. Loesche
G. J. Beemsterboer
E. G. Beard, Jr.
R. J. Rooney

After the aforementioned proceedings, the members went to the Blackhawk Grill. Following this the scene shifted to the Erlanger Theater, where the men enjoyed a fine performance of "Counsellor At Law." Chi Epsilon is the scholastic civil engineering honorary fraternity.

Phi Lambda Upsilon

WITH the return of practically all of last years' alumni, Phi Lambda Upsilon, honorary chemical engineering fraternity, has planned a most educational school year.

F. W. Paine, representing the chapter at the convention, at Denver, Colorado, has returned with an interesting account of the proceedings conducted by the gathering. The fraternity intends to aid in the formation of a new chapter at the Virginia Polytechnic Institute.

Sphinx

THE honorary literary society held a banquet and initiation last May at the Delta Tau Delta house. At that time officers for the 1932-33 year were elected. Jarl T. Sorensen is the present president, while R. F. Rychlik is secretary.

This honorary group elects its members from those students who have been active on the executive staffs of the school publications. Sphinx is wholly honorary; it has no administrative functions.

This year the group has decided to elect members in the first semester in addition to the regular second semester election, formerly the only one of the year. Sphinx, on Oct. 26, 1932, pledged the following men:

O. T. Barnett.
E. L. Curran.
E. E. Eberth.
M. J. Erisman.
E. P. Lomasney.

Pi Nu Epsilon

THE last meeting of the honorary musical fraternity in the past year was held for the purpose of electing officers for the present term: C. N. Clanton was elected to the office of president, while A. L. Steinhaus was elected vice-president.

American Society of Mechanical Engineers

THE Armour student branch of the society has planned a most interesting school year. Among the policies prevailing is one which will prove of great value to each individual member. Each student will have an opportunity to display his speaking prowess in some talk presented to the members at a weekly meeting. R. J. Dufour and H. J. Monger have presented topics of value.

An illustrated lecture by Mr. Erisman, of the Link Belt Company, on that firm's products, gave a thorough insight of commercial production.

Western Society of Engineers

THE Armour branch is considering itself fortunate in having members of several educational firms as their speakers. T. L. Condron, consulting engineer, has given the members a most thorough description of the University of Chicago's carillon construction. The motion picture

clearly illustrated the assembled structure.

In another talk, D. J. Brumley, president of the W. S. E., pointed out that specialties are obsolete. The society looks forward to the talk which will be presented by Arthur Consoer.

Fire Protection Engineering Society

THE Fire Protection Engineering Society concluded the activities of the 1931-32 school year with a business meeting at which the following officers were elected: J. T. Sorensen, President; O. W. Staib, Vice-President; C. N. Clanton, Secretary; B. Larson, Treasurer.

On October 21st the society was addressed by Mr. F. J. Prindeville of the Chicago Fire Prevention Bureau, who spoke on the subject of "Municipal Fire Prevention, and Current Practices of the Chicago Fire Department." Chief McDonald, head of the Fire Prevention Committee of "A Century of Progress," delivered a talk on "Fire Prevention Facilities and Construction of World's Fair Buildings," at the meeting of October 28.

The F. P. E. S. is composed of students of all classes in the Department of Fire Protection Engineering, and is addressed at frequent intervals by leaders in fire insurance and fire protection fields.

American Institute of Electrical Engineers

AT THE first meeting of the Armour Branch, R. F. Rychlik outlined his intention of obtaining profusely illustrated lectures on electrical devices during this season.

This feature has been partly realized by the Branch members. Mr. Maiers, an instructor in the Central Station Institute, gave a very clear address on "Air Conditioning" in his illustrated lecture.

Realizing the untold possibilities in the correct use of speech, Prof. Freeman has given several talks, and has advised the further development of public speaking to the Branch members.

American Institute of Chemical Engineers

THE national organization of the American Institute of Chemical Engineers has awarded Edmund Field, Ch. E. '32, a second prize of fifty dollars for general excellence in chemical engineering. Field obtained the place out of a competition of fourteen hundred students from twenty-three schools.

Several interesting inspection trips have been planned by the society. The research laboratories of Armour and Company will be inspected. Many new facts will be garnered at the Field Museum, to be visited shortly.

Armour Architectural Society

THE gayly-decorated Lincoln Park Refectory was the scene of the annual banquet of the Armour Architectural Society on May 26. The principal speaker was Mr. Charles W. Farrier, President of the Chicago Chapter of the American Institute of Architects, and also a prominent World's Fair official. Mr. Farrier, in an illustrated lecture, told of his expedition to Yucatan, where he gathered such material that he could design an exact replica of a Mayan Temple for the World's Fair. Earlier in the day, previous to the banquet, the freshmen were initiated into the society, but they retaliated somewhat by tossing a number of sophomores into Buckingham Fountain shortly after.

TECHNICAL ABSTRACTS

CONDENSATIONS OF LEADING ARTICLES IN THE TECHNICAL PERIODICALS WITH PERMISSION OF AUTHORS AND PUBLISHERS

Motors—High-Speed Standard or Low-Speed Special

By Walter A. Meyer

(From *Power Plant Engineering* Oct. 1932)

THE modern V-belt drive has contributed toward the elimination of the need for direct-connected special-speed motors. It permits the use of a high-speed, stock machine, whereas direct-connecting would require a heavier, more expensive special motor. On alternating current, the high-speed motor has better starting torque for a given horsepower, better efficiency and better power factor than the slow-speed unit.

That the standard high-speed machine with a large-ratio speed reduction is more economical than a slow-speed motor with a smaller speed reduction can be seen from the accompanying chart. The approximate combined cost of the motor and V-belt drive is plotted against the speed of the driven shaft or sheave in revolutions per minute. With the driven shaft speed definitely determined, it is possible to tell quickly what motor speed is most economical to use, or by subtraction to find the difference between any two given sets of equipment. Current prices were taken, based on standard squirrel cage induction motors complete with starter and rails, all of which are required for the average installation. It will be seen that the total price of the equipment decreases as the speed ratio increases.

To illustrate the point, if a given machine must operate at 400 r.p.m. with a capacity of 20 h.p., the chart indicates that a unit could be furnished utilizing a 900, a 1200, or an 1800 r.p.m. motor; the prices of the different units would be \$380, \$350 and \$320 respectively, showing that it is most economical to use the 1800 r.p.m. motor in conjunction with a large-ratio V-belt drive.

Not only is the initial cost lower in the employment of high-speed motors instead of the low-speed units, but the power factor and in many cases the motor efficiency is higher.

Changing the type or size of motor is much easier with the belt drive and accurate alinement is less essential than it would be with a coupled, direct-connected arrangement. Where speed reduction is slight, the cost of a V-belt drive is frequently no more or less than for a coupling, with the advantage of locating the motor in the most desirable position with respect to the driven machine.

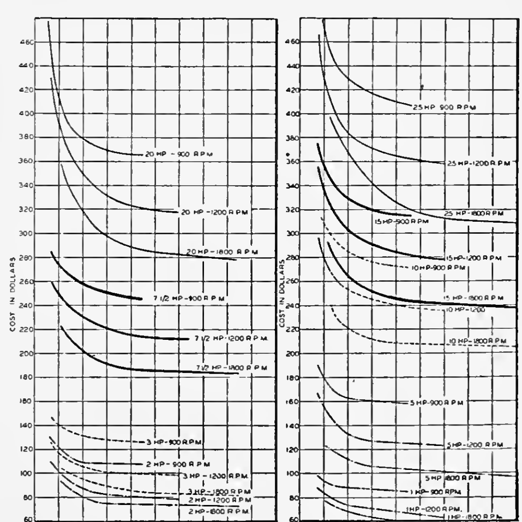


Chart of costs of motors for specific speed requirements.

Determining Friction Losses in Piping Systems

By Reed and Morrison

(From *Chemical and Metalurgical Engineering,* Aug., 1932)

WHEN water or any other liquid is pumped from a source of supply to a point of delivery, work must be performed not only to raise the water from the level of suction to the level of discharge but also to overcome a loss called "friction." This loss is caused by eddy currents in the liquid more than by scraping against the pipe walls.

A simple formula for the calculation of friction loss is the one usually named after Darcy:

$$H' = \frac{fLV^2}{2gD}$$

where $H' =$ friction loss in feet head of the fluid being pumped; $L =$ length of the pipe in feet; $V =$ average velocity of flow in feet per second; $D =$ internal diameter of the pipe; $g =$ acceleration due to gravity (approx. 32.2 ft/sec); and $f =$ a factor varying with the conditions of flow in the system. This formula is often used to show that friction varies directly as the length of the pipe, directly with the square of the velocity, directly with the square of the capacity, and inversely with the first power of the internal diameter. The first relation is obvious but the latter three are only approximately correct due to the inconsistancy

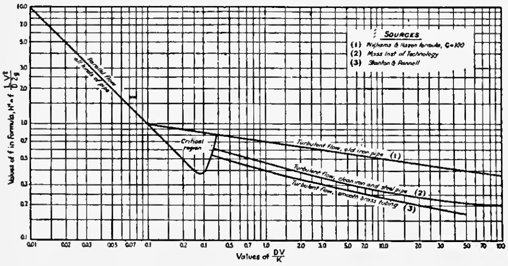


Chart of values of "f" for various pipes and conditions.

of the factor f with changes in V and D.

A prominent professor combined these factors: the velocity of flow, the internal diameter of the pipe, the viscosity of the fluid, and the specific gravity of the fluid, into a dimensionless factor. A modified form of this is VD/K where V and D are the same as before and K is the kinematic viscosity of the fluid expressed in centipoises, or the velocity in centipoises divided by the specific gravity.

The relationship between this number and f is best illustrated by Fig. 1. It will be seen that up to values of VD/K of about 0.01, there is a straight line relationship. This holds for all kinds of pipes and is known as the region of parallel flow. For values up to 0.35, the region of turbulent flow, the inside surface of the piping has a determining effect on f. Between parallel and turbulent flow is a critical region in which the flow is unstable and either parallel or turbulent depending on conditions.

Automatic Clutches

By Blanchard and Barry

(From *Motor,* Sept., 1932)

ALTHOUGH vacuum operated clutches vary considerably in detail, they all have the following features which are shown in the Figure.

When the clutch is fully engaged the piston has moved all the way to the left and there is atmospheric pressure of approximately 15 pounds to the square inch on both sides of the piston.

To disengage the clutch, the accelerator and cut-off plungers are lined up as shown, to provide a clear passage from the suction chamber to the intake manifold. With throttle closed, engine suction reduces the pressure in the suction chamber to about 4 pounds but since there is still 15 pounds acting on the other side, the piston is forced to the right and pulls the clutch out.

As the piston moves right, the pressure in the air chamber would be reduced. This would interfere with the motion were it not for the air inlet valve which allows air to enter this chamber, which maintains the air in the chamber at a pressure of approximately 15 pounds per square inch.

The vacuum operated clutch is designed to imitate the actions of the driver's foot under the conditions encountered while driving. Therefore the clutch is engaged in two steps: First, it is allowed to move rapidly until the friction surfaces are about to contact—call this the cushioning point. Second, at this point the motion is slowed so that the actual engagement is smooth. The first is accomplished by allowing the air to flow into the suction chamber by moving the cut-off plunger to the right. This cuts off the suction pipe and the air is allowed to enter the suction chamber to a pressure of 15 pounds. The piston is no longer pulling on the clutch linkage and so the clutch springs move the pressure plate up toward the friction disk.

Second step: While the piston is moving left the air in the air chamber flows out via the escape slot in the piston rod until the slot "runs out" through the leather bushing and shuts off the escape of the air. Then the trapped air in the air chamber is compressed until it stops the clutch at the cushioning point. From this point on, the rate of clutch engagement depends on how fast the air escapes through the bleeder slot in the accelerator plunger. This slot is so shaped that the more the throttle is opened, the faster the air escapes and the more rapidly the clutch comes into engagement.

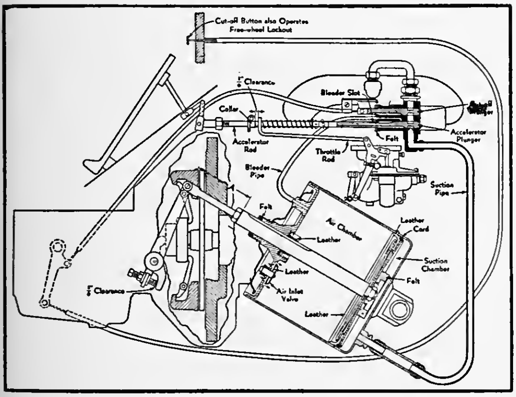


Diagram of essential features of the automatic clutch.

Combating Corrosion of Piping

By C. E. Joos and V. A. Rohlin

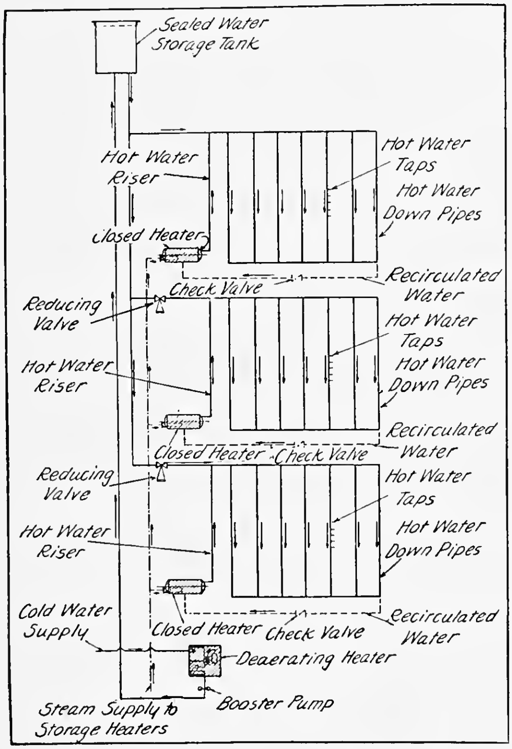
(From *Heating, Piping and Air-Conditioning*, Sept., 1932.)

WITH the present stress on economy in the industrial and commercial fields, failure of piping due to corrosion, and loss of capacity of piping from choking up because of the products of corrosion are receiving increased attention. Corrosive action is caused by the presence of oxygen and carbon dioxide in the water. Among the preventive measures which are available are the use of corrosion-resistant materials, chemical treatment of the water, and removal of dissolved gases by heat.

The method in which protection is afforded to piping by eliminating dissolved oxygen and carbon dioxide is called deaeration, and the apparatus used for this purpose is the deaerator. The deaerator is essentially a chamber in which water in finely divided form is brought into contact with steam by spraying or by flowing over trays. The water is heated to the boiling point by this intimate contact and the gases, being insoluble in water at this temperature, are removed from the apparatus by liberal venting. To accomplish complete removal of the oxygen and carbon dioxide, the water is heated to the full temperature of the steam, bringing about a water vapor pressure equal to the total pressure of the atmosphere in contact with the water surface. If

the water is desired at a temperature below atmospheric boiling point, 212°F, vacuum-producing equipment is employed for venting the steam-air mixture, or heat exchange apparatus is used. Thus if for hot-water service it is desired to maintain a temperature of 140°F, it is necessary to produce a vacuum within the deaerating heater corresponding to the boiling point at 140°F, or 24 inches of mercury.

To produce temperatures higher than 212°F it is only necessary to increase the steam pressure. Thus a deaerating heater operating at 60 lb. per sq. in. gauge will deliver water having a temperature of 307°F. Deaerators for the delivery of water at such temperatures are used in the preparation of boiler feed in steam power plants or for special processes.



A heating system utilizing deaeration method.

Rehabilitation and Improvement of Power Plants

By Charles W. E. Clarke

(From *Power Plant Engineering*, Oct., 1932.)

THE results to be sought for in rehabilitation work are: better combustion, heat reclamation, higher pressures, greater thermal efficiency and greater output.

The principal factors that have contributed to improvement in the economy of power production within the last decade are:

Increased knowledge of the fundamental principles of combustion which has resulted in better design of boiler furnaces and equipment for burning fuel; Understanding of heat reclamation devices such as air preheaters and economizers and the economic relations existing between the two, which decrease the loss due to heat rejected in the flue gases; Increase in the primary pressure and in the temperature or superheat of steam used for power production, resulting in an increase in the ratio of heat converted into work to total heat put into the steam in the boilers; Improvement in the design of prime movers so that their performance approaches more nearly the ideal and so that they can safely use the higher steam pressures and temperatures; Development of the binary cycle, notably the mercury vapor-steam cycle.

In connection with the fifth of these it might be stated that the mercury vapor-steam cycle has been developed to a commercially successful point. In this system, mercury evaporated in a fuel-fired boiler is expanded in a turbine which drives an electric generator and passes thence to a condenser. This system may be installed in an existing power plant and the steam produced by it used to replace that from uneconomical boilers.

Frequently it is necessary to increase the

capacity of an old plant by replacing all or part of the equipment. In such a case, consideration should be given to the installation of equipment of a modern type, designed for high pressure and temperature but to be operated for the time being at the same conditions as the old plant. This procedure leaves the way clear to secure a high efficiency installation when the old equipment is replaced, but makes use of the existing equipment for the full term of its operating life.

Diffusion Combustion

By W. M. Hepburn

(From *Metal Progress*, Sept., 1932)

THE "diffusion combustion" flame produces a moving cylinder of air having a core of gas. Combustion proceeds upon interdiffusion of oxygen which travels at the same velocity as the gas.

An "overventilated" flame, or one having an excessive supply of oxygen, pinches out in a dagger shape at the axis, whereas an "underventilated" flame flares out in a bell shape. Typical flame shapes for underventilated and overventilated conditions from a two inch burner are shown in the diagram.

The main distinctions between diffusion and combustion as compared to the methods of luminous combustion are:

1. Diffusion combustion holds practically a constant rate of radiation for its designed length of travel. Its emissivity is constant, combustion takes place at a constant rate, and the carbon precipitation is uniform.

2. The flame contains the greatest amount of free carbon possible with combustion, and the streamline flow of the gas and air strata insures constant conditions.

3. Diffusion combustion preserves a constant flame temperature for its designed length of travel.

4. A protective layer of sooty gas can be maintained constantly over the work being heated, thus effectually excluding oxygen and nitrogen of the air.

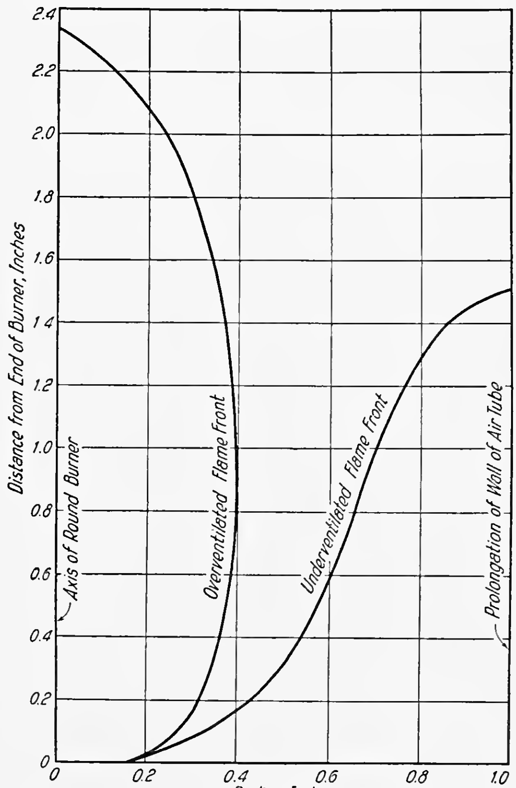
The practical value of these four distinctions will be in an increased rate of heating over the rate afforded by luminous combustion, a lower furnace temperature with correspondingly decreased maintenance cost, a more accurate control over unavoidable variations by the automatic temperature devices, and a better surface condition on the materials heated.

Waste Heat—Sometimes Its Utilization Is Uneconomical

By C. T. Baker

(From *National Engineer*, July, 1932)

SOME time ago the question of the electrification of a large plant engaged in the manufacture of paving brick, building



A chart of typical flame shapes from individual conditions.

brick and sewer tile was up for consideration and according to figures submitted by an engineer, a substantial saving in the cost of power could be effected by the installation of a number of electric motors to replace a 500 h.p. Corliss engine, while at the same time making provision for drying the brick and tile before entry to kilns by waste heat. In view of the apparent savings reflected in the preliminary investigation it was decided to have a thorough analysis made to determine whether or not, all things considered, it would be the economic thing to do to enter into a contract for purchased power.

An analysis of the application of waste heat drying disclosed that the most economical plan to meet the existing conditions would be the use of a waste heat boiler that would make use of the waste heat from the kilns for generating steam to be used in drying sheds. The next step was to determine whether or not there would be sufficient waste heat available to produce sufficient steam for drying operations. The first thing to determine of course was the amount of steam required to meet the drying demands. It was found that from 200 to 220 boiler horsepower would be required.

After a careful checking of the weight of waste gases at the temperatures available, it was found that under the conditions of operation as obtained during the period of investigation, only about 35 to 40 boiler horsepower could have been generated with waste heat.

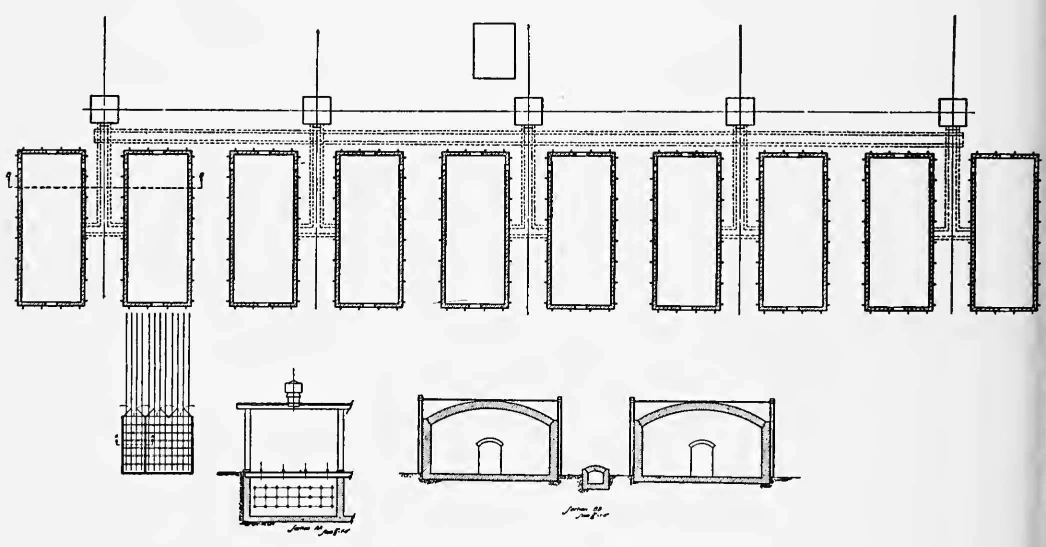


Diagram of kiln arrangement referred to above.

ENGINEERING PROGRESS

NEW DEVELOPMENTS AND DISCOVERIES IN SCIENCE AND INDUSTRY

New Observatory in Canada

THE details of the erection of what is to be the second largest telescope in the world were made public recently. The observatory is being built about a mile south of Richmond Hill, at an estimated cost of $500,000. It is a memorial to the late David A. Dunlap, and will be named the David Dunlap Observatory.

Officials of the University of Toronto, supervising the job, stated that work on the administration building would begin immediately. The administration building is to be one of the two chief buildings of the observatory, and is to cost in the neighborhood of $125,000. Materials for the erection of a circular building sixty-one feet in diameter, to house the huge telescope, are being constructed in England.

The two buildings will be located in the center of a 177 acre plot of land. The round building will stand on a circular platform 800 feet above sea level, while the administration building will be on a level five feet below, with the rest of the area three feet lower still.

The telescope, which will be larger than the one in use at the Dominion Government Observatory, is of the reflecting type. That is, instead of a lens, it will use a concave mirror to collect the rays of light from stellar bodies and bring them to a focus. The mirror will have a clear aperture of 74 inches, will be fashioned from a disc of glass 76 inches in diameter and 12 inches thick, and will weigh 5,000 pounds when finished. It was ordered from England two years ago, and although the construction is well advanced, a longer time than the three years estimated necessary to complete the mirror will be required.

In one of the smaller domes of the administration building it is proposed to mount the 19 inch reflecting telescope, recently constructed at the University of Toronto, while in another small dome there will be three astronomical cameras mounted on a single base. In the central dome of the administration building, it is hoped to mount a 10 inch refracting telescope for use in observation of planets, comets, occultations, and double stars.

Modern Stoker Development

UNDER competition with pulverized coal furnaces, underfeed stokers have shown remarkable development. Larger furnaces, and the use of preheated air have added to the economy of performance. Water cooling of furnace walls, in preventing most of the clinker and slag difficulties, has made possible higher heat release, and capacities have grown to meet modern requirements. The "world's largest" consists of a recent installation of 15-retort 69-tuyere underfeed stokers, each of which is 27 ft. long by 26 ft. wide, with a maximum capacity to burn 28.3 tons of coal per hour.

For free burning coals, lignites, anthracite and coke breeze, the forced-draft, traveling-grate stoker has its advantages. It is self cleaning, requires little power to drive, and has low draft pressure. Larger furnaces, arches set higher, and zoned air control to vary the pressure under the grates in accordance with fuel bed thickness, are some of the develepments responsible for

excellent performance. Stokers of this type are being used in sizes up to 528 sq. ft. of surface.

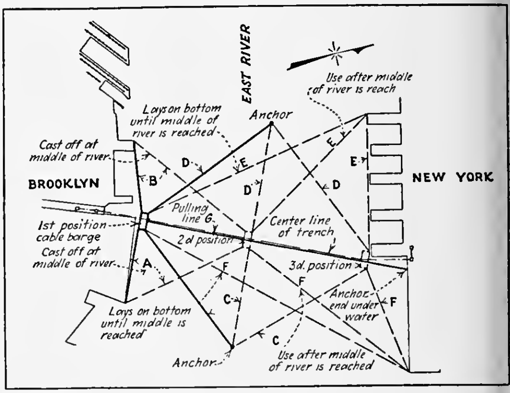
Improvement in stoker application has not been confined to the larger heating equipment. There has been great activity in stokers for small industrial and heating boilers. At one time it was not considered profitable to place stokers under boilers having less than 2,000 sq. ft. of surface, but now a great variety of designs are available for smaller units. In practice substantial savings have been effected over hand firing. To save labor and maintain uniform steam pressure, these units are under full automatic control. They are self-contained and readily adaptable to many different types of boilers. Furnaces of this type have operated at ratings up to 220 per cent, with heat release varying from 30,000 to 45,000 B.T.U. per hr. per cu. ft. of furnace volume. At normal ratings, efficiencies approximate 70 per cent.

Submarine Cables Laid From Special Barge

ACROSS the East River, in New York City, in water of 76 feet maximum depth, fourteen three-conductor, twenty-seven kilo-volt electric cables were laid this summer, to connect the Brooklyn and Manhattan stations of the light and power system. Seven of the cables are oil-filled and the remainder are of the solid type. At the point of crossing, work was made difficult by troublesome tides and eddies, and by dense river traffic which had to be avoided in carrying on the work.

Federal and local requirements made it necessary to lay the cables in a trench in the river bottom, ten feet wide, and three feet deep in rock and ten feet deep in mud and silt, the rock section being covered with concrete and the silt section backfilled. The cable trench was drilled from an anchored barge, blasted and excavated by a dipper dredge. Cables were delivered on reels in 2,330 foot sections, long enough for a continuous reach between manholes on opposite shores of the river. Laying of the cables was done from a barge whose movement was controlled by a system of lines to anchorages on shore and in midstream.

On the barge, the cable reels were mounted in cradles and the cables payed



Plan of movements of cable barge in East River.

out, two at a time, over a pair of parallel rollers on the stern of the barge, to prevent excessive bending of the lines as they descended to place in the trench in the bottom. Tugboats guarded the operations from interference by river traffic. The cable-laying proceeded as follows; The Brooklyn anchorages, A and B were slacked off, and lines C, D and G pulled in by winches on the barge. Lines E and F were left slack until the barge reached the middle of the river, when anchorages C and D served in place of A and B, which were removed, and lines E and F drawn up taut by the winches. By slacking off lines C and D and drawing up on lines E, F and G, the barge was moved to the Manhattan side.

To deposit the cable accurately in the trench, even when the barge was slightly off line, an adjustable cable guide consisting of parallel rollers, was lowered from a boom into the river and kept accurately on line.

Oil Overheating Avoided During Purification

THE purifying of circuitbreaker, transformer, or cable oil by passing it through a filter of centrifuge is greatly expedited by preheating the oil to reduce its viscosity. All operators do not use the same temperature, although it is commonly in the neighborhood of 50 degrees C. If the temperature ranges in excess of 120 degrees Centigrade it may injure the oil, although the injury is dependent on time of exposure as well as temperature.

Even though the entire body of oil does not come into contact with the heating units, that film which does may be heated above what is considered a safe temperature, if units with a high heat dissipation per unit of contact surface are used. This injury to the oil is minimized to a certain extent, however, by the brief time of contact although many uses of oil, such as in high-voltage transformers and oil-filled cables, cannot tolerate any injury.

A manufacturer of oil filled cable, while experimenting with a purifier equipped with oil-immersion heaters, found that the comparative ohmic resistance of the purified oil fell off materially after treatment. Upon closely delving into the matter, he found that this change was caused by the oil coming in contact with oil-immersion heaters having a high watt density per square inch of contact surface.

As a remedy for such trouble, a heater has been designed which is inherently proof against causing injury to the oil. Indirect methods of heating are embodied in the design. Water is used as the heat transfer medium because at atmospheric pressure it cannot be heated above 100 degrees C. Due to the large area of contact between the oil in the copper tubes and the water outside there is no excessive temperature gradient. The actual density of the heated surface in contact with the oil is less than 6 watts per square inch, compared with 40-50 watts in some immersion heaters. Should the flow of oil stop, the final temperature cannot exceed that of the water. The heater can be made automatic by installing thermostats in the water and outgoing oil.

In the diagram shown oil enters the outer casing and circulates up and down the height of the tank through a system of baffles. It completes a circuit of the tank before it enters the copper coil, where it is heated by the surrounding water in which the immersion units are submerged. The outer jacket of cold oil minimizes the heat loss. Test runs on this apparatus have proven that the principle is right and that the heater is highly efficient.

Curing Rubber Products by Electric Heat

DURING the manufacture of rubber products one of the most important and difficult operations is to cure the rubber at a temperature of approximately 310 degrees Farenheit while under a very high pressure. One method of doing this is to place the rubber in steel molds between platens of hydraulically operated presses heated by steam at about 65 pounds pressure.

A certain manufacturer of rubber specialties in order to increase the capacity of his plant was confronted with the necessity of either overhauling his steam plant or installing new apparatus. After experimenting with several installations he equipped all his presses with automatically controlled electric heaters. This brought a heating load of 40 kw to be supplied by the power company.

After a year's operation the following have been found to be some of the most noteworthy advantages of electric heat over steam heat for the platens:

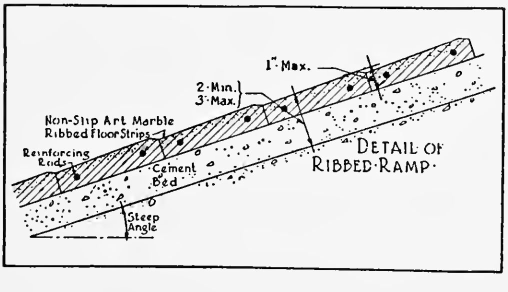
The cost of the finished material is less;

the material is more uniformly cured; a more constant temperature control has been made possible; better working conditions. Overheating, humidity and damp floors have been eliminated; longer working of individual presses. A saving in insurance rates and space due to the use of electric platens; boiler trouble is eliminated; a clock automatically throws on the power at certain times; the heaters are also automatically disconnected at the end of the day.

Precast Concrete Ramp Units

A PRECAST concrete unit for ramp surfaces subjected to heavy foot traffic has been developed in recent years, and has been successfully used in locations which have put it through more than the usual wear of ordinary ramps. The development of the unit was the result of a conference between a number of architects, engineers, and manufacturers, when, after a great deal of study on the subject, no suitable material could be found.

Before a complete ramp was built of the new unit, a sample specimen was set and tried out under continuous foot traffic for several hours daily. This sample surface was found to be successful in preventing slipping, thus providing a safe walking surface. It withstood this wear admirably. As a result, the complete ramp was resurfaced with the new unit. Since its original installation, similar units have been laid on ramps in a number of important buildings, and favorable reports continue to come in as to its behavior. One of the main ramps, it is installed in, carries a great volume of foot traffic which arises from the suburban passenger business. Another walkway carries the greater part of the traffic that enters and leaves a railway station.



As the drawing indicates, the unit has a maximum thickness of $1\frac{1}{4}$ inches and an average thickness of fully 1 inch. Its width is 5 inches and the usual length is three feet, though the length may vary. In cross-section the ramp unit is similar to a washboard surface on a large scale, the rib providing a positive grip for the foot of the pedestrian. Special abrasive materials are mixed with the concrete and colored stone aggregate to aid in the prevention of slipping. Each strip is adequately reinforced with steel rods. The ramp unit is laid in a bed of cement-and-sand mortar. The walkway is usually laid with a crown and with gutters along the walls so that when the water is washed down it is carried to the drains.

The unit is a high-class concrete specialty and, in the manufacturing process, it is cast in molds under air compression and vibration. The unit is then passed through a series of operations involving its curing, filling, and finishing, after which it is ready for distribution and installation. The units are made in any color specified.

Bearings That Lubricate Themselves

TO ELIMINATE the constant oiling of moving parts, a new kind of bearing has been invented, which is always "oil-full" rather than "oil-less." This bearing carries its own oil, and acts as automatically as an electric clock to produce the oil at the proper time and place.

This new bearing, which actually contains from 30 to 35 per cent of oil by volume

is made from pure virgin copper in the powdered form, to which are added tin and graphite. The materials are weighed out according to a formula and briquetted under a pressure of 50,000 pounds to the square inch. It is then given a special heat treatment under which the briquette changes characteristics and color, and is transformed from a mechanical mixture to a bronze.

After the bearing has been heat-treated, instead of being weak and fragile, it is exceedingly tough and ductile, and will withstand a vast amount of abuse. At the same time, it is porous enough to hold 30 to 35 per cent of liquid by volume, which may be anything from kerosene to "600W" oil. The porosity does not prevent the bearing from approaching the strength of a cast bronze bushing of equivalent dimensions.

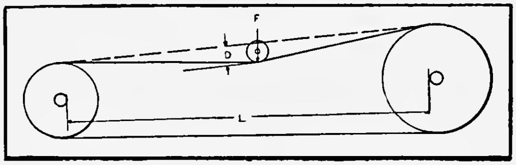
If the bushing is placed in a vise and squeezed, a thick coating of oil will rise on the surface, which demonstrates the point that if the bearing is subjected to a load or pressure, lubrication is immediately supplied. At the same time, the bushing will withstand a unit pressure of possibly 4,000 to 6,000 pounds before it will reach the point of failure.

Determination of Belt Horsepower

A METHOD has been devised by which a close approximation can be made of the horsepower required to drive any belt-driven machine, regardless of the type or material. Given the simultaneous total tension on the tight and slack sides of a belt drive, and the speed of the belt which is easily determined, it is simple to calculate the actual horsepower being transmitted. The problem consists of finding the belt tensions, which can be done, not only when the machine is idle, but when it is in motion.

A light idler is pressed against the mid-point of the belt until it deflects any convenient distance D. This deflection is measured, and also the force F in pounds required to produce that deflection and the distance L between the points of tangency on the pulleys, in inches. To determine the belt tension, multiply the force F, in pounds, by the distance L, in inches and divide this product by the deflection D. The result is the tension on that side of the belt, in pounds. The tension on the other side is obtained in precisely the same way, and greater accuracy can be acquired if the measurements are made on both sides of the belt at the same time.

Finally, to calculate the horsepower transmitted, multiply the velocity of the belt, in feet per minute, by the effective pull which is the difference in tensions of the slack and tight sides of the belt. This product divided by 33,000 gives the horsepower transmitted. Belt velocity can be determined from tables commonly found in handbooks, or can be calculated as 3.1416 d N, where d is the diameter of the pulley in feet, and N is the number of revolutions per minute made by the pulley.



A new method of finding belt h.p. required.

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JAMES G. COONEY, an alumnus, presents in this issue "Vital Considerations in the Development of Illinois Municipal Water Systems," which is an abstract from his thesis bearing the same title, written this year for his professional degree of Civil Engineer. In 1926, he assumed his present position of assistant to the president, in charge of the St. Louis office, for Consoer, Older, & Quinlan, consulting engineers of Chicago.

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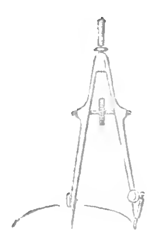

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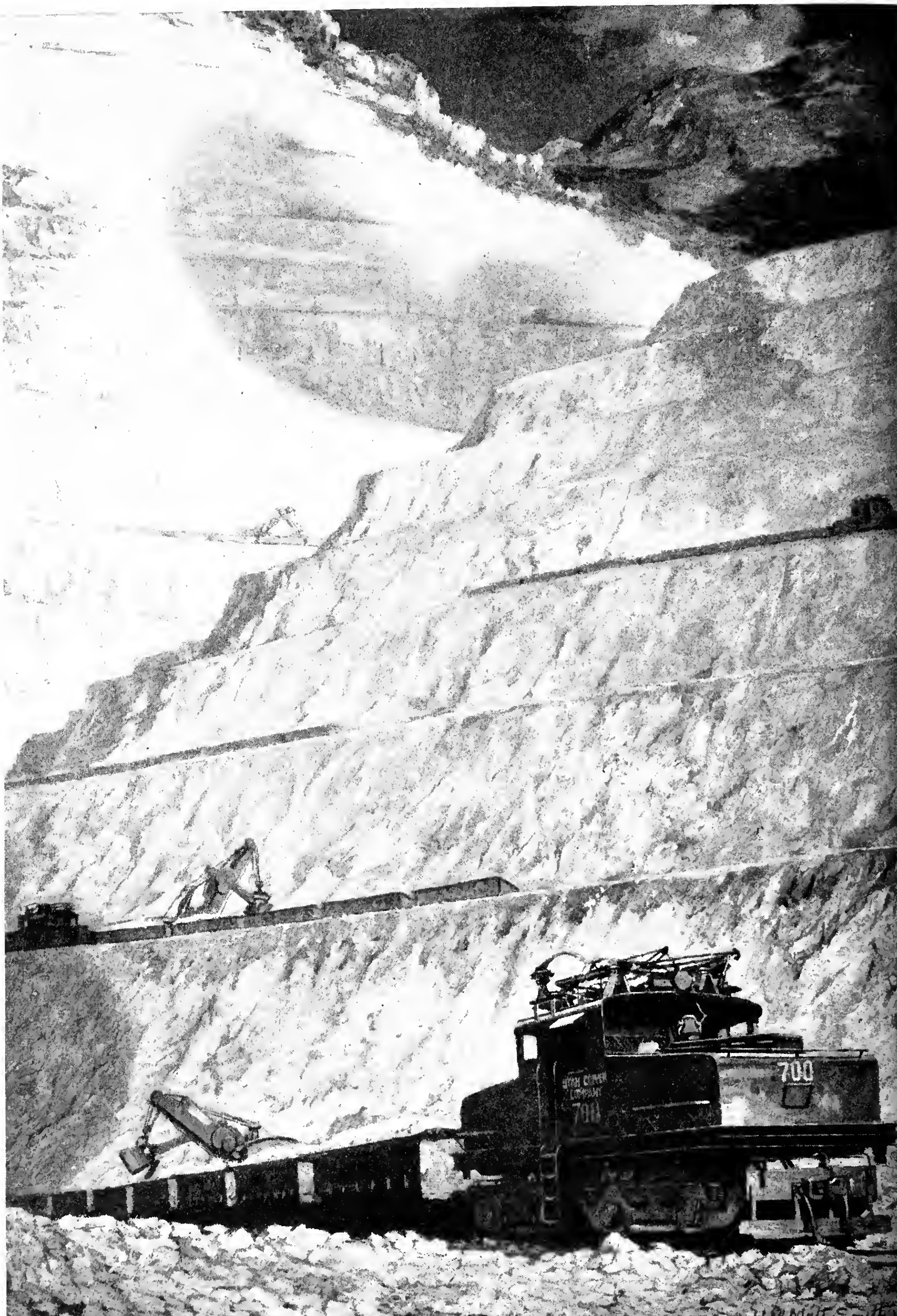
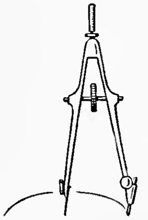


Open Pit Copper Mine at Bingham Canyon, Utah

THE

ARMOUR ENGINEER

JANUARY, 1933



Development of Stainless Steels and the Present State of the Art

By DR. M. A. GROSSMANN

THE steels classified as stainless steels today embrace a much larger group than the original stainless steels. The original ones were those discovered by Brearley, and used mainly in cutlery. They were termed "stainless" because they showed no stains when subjected to the action of fruit juices and other foods. Gradually however the name came to be applied to other corrosion resisting steels as well, partly because they remained bright under corrosive conditions even if they were not truly stainless, partly because the name "stainless" was a striking and convenient term, and partly because they were all high-chromium alloy steels as was the original stainless. Today we find the various stainless steels used in four major applications,—for architectural purposes, for chemical equipment, for places where cleanliness is demanded as in kitchen installations and in hospitals, and for high-temperature service.

Stainless steel proper,—that is, the cutlery steel—became known here soon after its development in England. Patented in 1915, it became known after

the war in kitchen knives and then in table cutlery. By 1920 to 1925 it had become a firmly established material.

In manufacture and in mechanical properties, this cutlery steel was rather similar to some of the tool steels. Its manufacture therefore was shortly on a sound basis in the regular tool-steel mills, and its mechanical properties, too, were soon well known by fabricators and users. In melting in electric furnaces, it behaved much in the same way as any high-grade steel, and in casting and rolling it was quite orthodox. It is rather stiff at steel-rolling temperatures, but this property was already familiar in high-speed steels and related hot-die steels. The annealing, too, could be carried out as in ordinary steels, and grain refining was accomplished as usual by a normalizing operation (i. e. heating to say 1750°F. and cooling in air). This point should be stressed—this simple way in which cutlery steel fitted into normal manufacturing operations, because of its contrast with the radically different behavior of the other stainless steels, developed later. These later steels, the 17% chrome steels and the 18-8 chrome nickel steels, required considerable development work.

A simple metallurgical concept in these steels explains why the cutlery steels behaved quite regularly whereas the later stainless steels did not. When ordinary carbon steel is heated, it undergoes a change in its crystal structure at some elevated temperature, such as 1400° to 1500°F. depending on its carbon content. Below this critical temperature, it consists largely of ferrite, but above the critical temperature the structure is austenite. The significance of this change in structure, this recrystallization, is that it makes possible a refining of the grain size, by a simple heat treatment, and the refining of grain size is important because it causes greater toughness. Thus when ordinary carbon steels have been made coarse-grained and brittle by overheating in some manufacturing or fabricating operation, they may be made fine-grained and tough by a mere heating through the aforementioned critical temperature, following by cooling. The *cutlery* stainless steels behave in this way.

But the other stainless steels are radically different. One group of them are largely ferritic at *all* temperatures, and the other group are largely austenitic at all temperatures. This means that there are no critical temperatures in the ordinary sense, that no recrystallization is possible by heat-treatment alone, and that such grain refinement and toughening cannot be accomplished. The straight-chromium stainless steels, of which 17% chrome is typical, are largely ferrite at all temperatures, from room temperature up to the melting point. The chromium-nickel stainless steels, of which 18-8 is typical, are substantially austenitic at all temperatures. In order to keep these steels fine-grained and tough, one must refrain from working them at excessive temperatures.

The 18-8 steels have several additional idiosyncracies, all associated with their austenitic structure. For one thing, they are unusually ductile, so that in sheet form they may often be drawn into shapes that are not possible with carbon steel. On the other hand, when they have been hardened by cold-working, they call for an annealing temperature well above that employed for carbon steel—they must be heat-treated at 1850°F. or higher for maximum ductility. Also, they are unusually susceptible to hardening by cold-working, a property which interferes with easy machining. These peculiarities made tremendous differences in manufacture and in fabrication, and new methods of treatment had to be devised. It should be mentioned also that these 18-8 steels are non-magnetic.

In about 1925, 17% chrome steel faced its first large commercial development, in a large installation for fixation of atmospheric nitrogen and manufacture of nitric acid. Due to its different nature, however, a number of unexpected difficulties arose,—it was sometimes unsound in ingots, it was too soft in rolling, it was soft yet brittle when cold, could not be welded, nor riveted, nor pickled uniformly. The unsoundness of ingots proved to be due to gas content, and this condition could therefore be cured. The

The 18-8 chrome-nickel steel facing on the Empire State Building

excessive softness in rolling was compensated for, by using different rolling methods. The brittleness at room temperature was found to be due to two conditions which resulted from the usual finishing temperatures in rolling or forging. One of these conditions causing brittleness was coarse grain due to exceeding a certain high temperature, the other was a moderate proportion of hard martensite in the structure, due to exceeding a certain lower temperature. Both conditions could be corrected,—one by avoiding excessive temperatures, the other by annealing. The welding presented a difficult problem, and is one which even today imposes limitations on this grade of steel. One of the difficulties is that in fusion welding, the temperature necessarily reaches and exceeds the temperature at which coarse grain develops. This coarse-grain temperature, 2200°F., is the temperature at which the small areas of austenite disappear, and the structure becomes uniform delta iron or high-temperature ferrite. These ferrite grains grow to enormous size, and are the cause of some brittleness. Annealing effects some improvement, enough to be satisfactory for some purposes, but the condition is one that must be borne in mind. The other major welding difficulty at the time was that 17% chrome steel did not weld satisfactorily with welding rod of the same composition. It was found, however, that it would weld quite well if the welding rod was of the 18-8 grade of stainless, 18% chromium with 8% nickel.

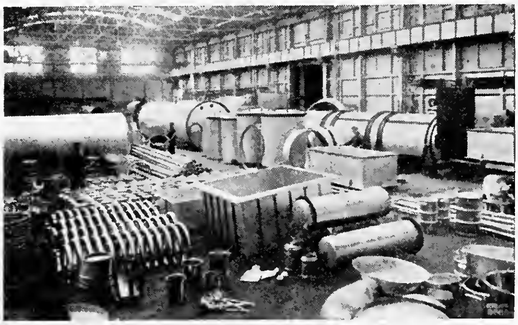
However, because of the uncertainty of welding and the danger of brittleness in the welding zones at that time, it was decided to resort to riveting. It was discovered at once however that when the rivets were heated and driven in the ordinary way, they would often crack and fly off shortly after driving, though on the other hand some were wholly satisfactory. The answer to this problem was found in the temperature to which they were heated for driving. If the temperature reaches 1800°F. some martensite forms in the structure, and these areas of hard martensite lower the ductility of the steel. If the heating of the rivets is restricted to some lower temperature, however, then martensite is absent, and the riveting was carried out successfully when the heating instructions said "not more than 1700°F."

The pickling of the steel presented problems also. At times a very tight adherent scale would form in some spots, and in order to pickle these spots clean, it would be necessary to over-pickle the rest of the plate, resulting sometimes in bad pitting. This condition was overcome by sandblasting the scale from the regions where its amount was excessive.

This use of 17% chrome steel on an extensive industrial scale, was soon followed by another large-scale development of the same steel. This steel exhibits resistance to oxidation at high

temperatures, and good strength at somewhat elevated temperatures. It seemed that these properties would be useful for distillation tubes in oil-cracking stills for making gasoline, and also as superheater tubes in boilers. The making of seamless tubes was therefore undertaken, and it was not long before many thousands of tubes were in service, and were establishing very high efficiencies in high-temperature processes. But now an entirely unexpected difficulty arose. Reports appeared that the steel was becoming as brittle as glass. It developed that the 17% chrome steels have a dangerous temperature, at about 900°F., where they develop brittleness upon long exposure. The range of temperature is quite narrow, since the steels show no deterioration up to 800°F. nor above 1000°F. Furthermore, the effect appears only after a long time. Several weeks at 900°F. are required before any change is noticed, and even more before it becomes serious. The steel is not brittle while at temperature,—it exhibits the brittleness only when cooled to room temperature. In the above application, the condition was discovered only when the tubes were cooled for cleaning. They then began to break when scrapers were used to remove incrustations of carbon. The condition is still unexplained. It is common to all the straight chromium, high-chromium steels, and is more pronounced the higher the chromium. Thus 27% chrome steels show it markedly, 21% chrome steels less so, 17% chrome steels show it to some extent, and it has been found even in the 12% chrome steels. There are several theories about the condition, but none has been proven. In any case, "Avoid straight-chromium steels for a long exposure in the immediate neighborhood of 900°F." It should be pointed out that steels which have become brittle in this manner may be made tough again by heating to above the dangerous range.

The above difficulties led to application of 18-8 steels for this purpose (18% chromium and 8% nickel). Their strength at elevated temperatures was better than that of 17% chrome, and the oxidation resistance and corrosion resistance were at least as good. The toughness of the 18-8 was also satisfactory. The steel was so satisfactory in other respects also, such as workability and ease of fabrication, that it has now become a standard steel for oil-cracking service. It is widely used for this purpose today and is the preferred steel in many gasoline refineries, functioning well in the tendency toward higher temperatures.



18-8 chrome-nickel chemical apparatus.

It should be mentioned that 18-8 has one drawback for this service: a reduced ductility at certain high temperatures. This introduces a fire-hazard for the following reason. In former times, when carbon steel was used for this purpose, the steel gave evidence of impending failure by starting to bulge at the weak spot before failure actually occurred. Since this bulging took place for 2 or 3 days before failure, the regular inspection of the stills always discovered it and the still was shut down and repaired. Now in the case of 18-8, the ductility at temperatures around 1400 to 1700°F. is not very great. As a result, if the still is fired carelessly or is allowed to overheat, the 18-8 may rupture without warning, there being no preliminary bulging such as occurs in carbon steels. If the still tubes fail while the oil is under pressure, an explosion occurs, and there have unfortunately been a few very serious occurrences of this nature. However, care in supervision of the stills avoids this hazard altogether, and there are many thousands of 18-8 still tubes in oil-cracking service, without a single serious accident of record in the past 2 or 3 years. It should be mentioned that some refiners are using for this service, a lower-chromium straight-chromium steel (4 to 6% Cr), which has shown creditable performance at temperatures up to 1100°F.

The above development of 18-8 still tubes has been described in some detail because it was the first large tonnage application of 18-8. This was in about 1928. A year or so later came the second large tonnage application. One automobile manufacturer decided to use 18-8 stainless for radiators and trim. The 18-8 has most unusually high ductility, so that parts could be deep drawn from this steel which were not possible even with the best deep drawing plain carbon steel auto body sheets. Further, the lustre and color were very pleasing when finished.

In this particular case, the most economical procedure involved the steel manufacturer furnishing the sheets to the consumer merely in the pickled condition, without polishing. The forming and fabrication were then carried out, and the polishing done thereafter on the finished article, all at the plant of the automobile manufacturer.

This application of 18-8 stainless for automobile exteriors was an important step in the development of this steel, because it was the first industrial demand in what might be called tonnage quantities in sheet form, calling for regular output on a large scale.

However, applications had already been developed in other directions on a moderately extensive scale. Indeed some of these applications were reflections of the large-scale pioneering work done on this steel by its originators in Germany, and we find numerous uses of 18-8 developed in Germany which find equal application in this

country. Principal among these is chemical apparatus. We have already mentioned the use of 17 Cr for nitric acid equipment. The 18-8 grade had equal resistance to nitric acid and even greater possibilities for numerous other chemicals.

An industry where 18-8 has proven to be particularly adaptable is the manufacture of paper. Here the paper pulp must be kept clean, and free of discoloration, and the 18-8 steels are giving excellent satisfaction in resistance to the sulfite liquors used there. The ductility of the 18-8 also enables it to be drawn into fine wires, so that it may be used in wire mesh for screens and filters.

That there are many diverse chemical uses for this 18-8 steel is shown in the accompanying figure. This is a view of a corner of the shipping department in the plant of the leading German manufacturer. Details of the various other kinds of chemical equipment are too numerous to record.

For architectural and structural purposes, perhaps the first attempts were store fronts of modern design. These made use of stainless steel because the silvery sheen fitted well into the modern manner. Stainless steel in store fronts and display windows is now a familiar sight.

The first widely publicized use of stainless steel for weather resistance was on the Chrysler Building in New York City in 1929, followed shortly by the Empire State Building of New York City in 1930. Since these are in a sense test cases, and have been in the weather now for several years, it may be of interest to discuss them in some detail.

The Chrysler Building employed the first large quantities of stainless steel for exterior surfaces. All of the roof and the sides of the tower on the upper part of the building are of 18-8 stainless. A considerable quantity of stainless is also used around the windows on the upper floors. In addition, there are the other more usual applications such as the shop fronts, the entrance doors, and the interior of the lobby. The behavior of the steel on the upper floors, where it has been exposed to the weather for three years, is of interest. The extent to which sunlight is reflected shows that the bright metallic surface is retained well, though there is a slight dulling which has removed the brilliant glare which was present when the building was erected. The steel shone so brilliantly in the sun, at first, that it has been stated that several law suits were pending, instituted by occupants of offices on high floors of nearby buildings, who experienced some discomfort because of the glare. The glare has now subsided, however, partly because of the usual deposits of dust, and partly due to a slight dulling of the surface. Of course, streaks due to rain and dust are unavoidable, but the metallic lustre is well preserved. In a number of places, parts were joined by welding. These welded places have held well, and there are

no signs of destructive corrosion.

Under these circumstances it is interesting to have another instance of several years of service of stainless steel in the weather on a tall building. The Empire State Building was likewise examined recently. The accompanying figure is a general view showing how the steel shines brightly in the sunlight, the lustre of the steel being very well preserved. Indeed, it must be said that the stainless steel on the Empire State Building has preserved its original lustre even better than that on the Chrysler Building, an index of the increase in knowledge of the art obtained in the year which intervened between the erection of the Chrysler Building and that of the Empire State Building.

An unusual instance of corrosion on the Empire State Building should be reported, as illustrating how a set of untoward conditions may wreak havoc in even the most corrosion-resistant material. Shortly after the building was completed, large patches of red rust appeared all over the surface. This was most unexpected, because the steel had been tested under severe conditions prior to installation on the building. Test coupons cut from every one of the sheets had withstood 100 hours in the salt spray test without any signs of rusting. This test is so severe that it will discover any surface defects in the steel. Careful study of the rust on the building showed it to be due to an unexpected circumstance. Corrosive ingredients were found in the cement used in the construction of the building. Rain storms had washed some of these corroding agents out of the concrete, together with some of the iron rust from the structural steel, and this had run down on to the stainless steel. As a result, patches of rust as large as one's hand were found in numerous places on the stainless steel all over the exterior of the building. The corroding agents from the cement caused the stainless steel to be mildly affected. When it was discovered that this was the cause of the rust spots, it was hoped that after a short time the intermittent rains would wash out substantially all of the corroding agents from the concrete, and that the rusting would then stop. This conjecture proved to be correct. The stainless steel was washed and wiped a few times at intervals of several months, and corrosion finally stopped. In the recent examination of the building, it was found that the stainless steel was entirely clean, only the minutest traces of rust spots being found, and these only at widely separated points.

Another recent interesting example of architectural application is found in the Earl Carroll theatre in New York City.

These applications of stainless steel are also particularly suitable for elevator doors, since the steel is serviceable and fits in well with the modern manner of design.

Another application for interiors which is now well-known, is the use of

stainless steel in bank buildings, bank vaults, safes and the like. There are numerous installations all over the country.

A striking recent development in stainless steels, involving both structural design and appearance, is incorporated in a new design of railroad cars, called the Budd-Michelin cars. These are constructed of 18-8 stainless, both for the structural members and for the exterior. The cars are extraordinarily light, a complete passenger car weighing only 18,000 lbs., compared to 75,000 lbs. for the ordinary railroad passenger car. The lightness is made possible by an unusual design of the stress members. These are made of 18-8 stainless strip, formed and welded into sections designed for high stress resistance, while still being relatively very light. The welding is a special process called "shot welding."

The exterior of the car is entirely 18-8 stainless. The car is so light that it became possible to run the car on rubber tires, and this provides comfort and quiet. Cars of this type are being built at the rate of two or three a month for use in this country. One of them has been in regular railroad service between Camden and Pemberton, New Jersey, for some time.

There are numerous other places where stainless steel is finding regular application. One of the well-known uses is kitchen equipment, and another is in hospitals.

Stainless steel is also coming to be used rather extensively in the dairy industry, for example for milk trucks and milk coolers.

Another application has been developed by the dentists, for use in dental plates, crowns and inlays. In Germany, the 18-8 stainless has been used extensively in this manner. Its use has recently begun also in the United States. Discussion of this matter with a dentist elicited the following rather interesting information. Metal plates are much more desirable than rubber ones, because of the heat conductivity of metal. This thermal conductivity permits the mouth to be properly sensitive to the temperatures of hot and cold foods taken in, and also causes the plate to conform much better to the shape of the mouth, even with abnormal mouth conditions. Until recently the only suitable metal was gold. Now using 18-8 stainless, the plate can be made much thinner because of the superior strength of the steel, and is thus much lighter than the gold. Furthermore, it costs only one-fourth as much. In manufacture, the dentures are made of swaged plates, pressed in a machine under 60 tons pressure. Separate parts are spot welded. There are stations in New York, Chicago and San Francisco.

There has been considerable experimenting with other alloys which are added to the straight chromium steels and to the chromium-nickel steels, in an effort to further increase the resistance of these steels to chemical attack. It must be said that, compared to the major effect of chromium

and nickel, the effects of these other alloys are relatively minor. It is true that certain special properties can sometimes be secured, and their importance should not be minimized. On the whole however, the basic properties of the stainless steel are determined by the chromium and the nickel. Alloys other than chromium and nickel have been added as follows. Molybdenum has been used in amounts up to about 3%, for improving certain kinds of acid resistance. Copper has likewise been used in amounts up to 1% in an attempt to improve certain acid resistance. Tungsten has been used in amounts up to about 3 or 4%, in order to increase the strength at elevated temperatures. Silicon has been used in amounts up to 2% to improve the resistance to oxidation or scaling at elevated temperatures. Manganese has been used in various amounts from 2 to 8% to improve the ductility.

Mention should also be made of the use of titanium to reduce intergranular corrosion. This intergranular corrosion, which at the same time causes a drastic loss of ductility (embrittlement), is a special type of deterioration which may set in when 18-8 stainless has been heated in the range of approximately 1200 to 1400°F. Its nature is perhaps too involved to be discussed at length here and it may suffice to say that it is a secondary effect arising from the precipitation of carbides, which is the primary effect of this heating. The addition of certain small amounts of titanium prevents the secondary effect, although the primary effect (the precipitation of carbides) still takes place. A similar improvement may be obtained from vanadium, although it is not as effective as titanium.

Many of these alloys will presumably find their ultimate proper applications in the stainless field. For the present, the chromium steels and the chromium-nickel steels are already on a sound production basis, and have become an established part of industry.

Lightning, A Review of Progress Made in Its Study

By PAUL J. THOMPSON

LIGHTNING, most destructive of man's natural enemies, is slowly but surely yielding up its secrets to the modern engineer. He has removed it from the realm of the "medicine man" and placed it on an engineering basis of volts and amperes, although the electrical quantities involved are of an order of magnitude far in excess of those met with in ordinary practice. He has pictured the wave shape of lightning and determined the attenuation while the wave travels along a transmission line. The time required for a cloud discharge has been measured. Natural lightning waves have been reproduced in the laboratory, where their effects on transformers, insulators, and transmission lines have been studied at will. A host of measuring instruments, planned with an eye to the final solution of the lightning problem, have been devised.

Using specially constructed generators, with a potential of two million volts, sparks twenty feet long have been obtained, but as compared with a lightning flash several miles in length, the results indeed seem puny. However, the results obtained in the laboratory enable us to analyze phenomena occurring in nature, and obtain a clear picture of the mechanism involved in the formation of lightning flashes.

The conductivity of the atmosphere is due to the presence of ions which, when acted upon by an electric field, produce a current. If it were not for these charged particles, air would be a perfect insulator. Ions are always present in air, as it is subject to spontaneous ionization by cosmic rays or traces of radio-active material.

When the saturation current is not reached the current is proportional to the voltage gradient and the cross section of the path. That is

$$I = kGA$$

where G is the voltage gradient.

Under increasing voltage, the saturation current is soon reached and when the voltage gradient reaches 76 kv per inch, the current suddenly increases, due to the cumulative effect of collision ionization. The ions present in the field are then so accelerated

so as to possess sufficient kinetic energy to produce new ions when they collide with neutral atoms. The ions, when free, are acted on by the electric field and are equivalent to a current. The current depends on the proportion of free ions and also on the temperature.

As conductivity increases in accordance with the formula

$$g = kAf(i,t)$$

where g is the conductivity, A is the cross section of the path, and f (i,t) is a function of the current density and the temperature, it follows that for higher temperatures the current density will be increased. This means that, assuming the discharge along a cylindrical path, in the restricted space along the axis, the rate of dissipation of energy, and hence the temperature, will be increased; so finally, the discharge will be concentrated in a thin crooked filament that we know as lightning.

Before lightning can be handled properly, a knowledge of actual lightning strokes must be secured and many records taken, so conclusions can be drawn. Because of the variable nature of the strokes, and their infrequent nature, record taking in the field is exceedingly difficult. To overcome this obstacle, engineers began constructing surge generators that would throw high voltage flashes into transmission lines.

In 1928, a 1,000,000 volt generator made up of eighty 25,000 volt condensers in series, repeatedly shot flashes into a transmission line of the Turner Falls Power and Electric Company. The purpose of the test was to determine how well protected the line was from lightning, and marked the first time that lightning had been hurled at a high tension line carrying full voltage.

Another lightning generator, capable of producing 5,000,000 volts, has been built and waves of 3,600,000 volts from it have been shot into transmission lines to test full size transformers and generators for lightning resistivity. The method consists of adding two, three, four, or more of the generators at the correct instant so that all the impulse voltages add together. Alternating current voltage is applied to the unit generators directly. At the instant on the crest of the wave when each unit is fully charged, gap sparkovers take place connecting the generators in series and the impulse occurs. Connections are as shown in Figure 1.

The condensers C_1, C_2, C_3, of the generators are charged to a point which approximates closely the gap setting G. Sparkover occurs on G_1 and is immediately followed by sparkovers

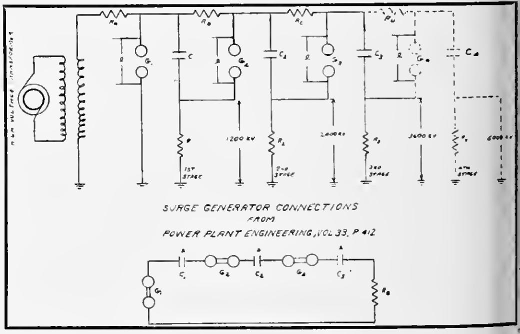


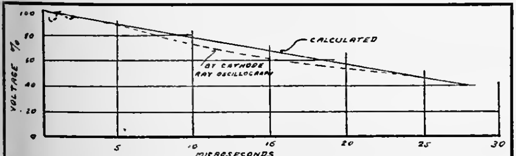
Figure 1

on G_2 and G_3. The resistances R_a, R_b, and R_c, R_1, R_2, allow the small 60 cycle charging current to pass, but are infinite to an extremely high impulse current. The result is as shown in the second figure; only three gaps being in series for 3,600,000 volts, and four for 5,000,000. The wave shape, of course, depends on R, L, and C in such a circuit.

With this apparatus, waves varying in duration from a few microseconds to 1,000 microseconds were experimented with and the maximum energy of any stroke was found to be 14,000 watt seconds. Actual work of this type on the effect of lightning transients on transmission lines was started in 1928, when engineers of the General Electric company succeeded in obtaining an oscillogram of a lightning stroke of 2,500,000 volts.

An extremely important element in lightning studies is wave shape. This, in the first studies of transients, could not be pictured directly but had to be calculated by a rather laborious, and not altogether accurate method. Now, the cathode ray oscillograph affords a means by which wave shapes can be readily ascertained.

The steeper the wave, or the shorter the duration of the transient, the higher is the crest sparkover voltage.



LIGHTNING WAVE OF 3,600,000 VOLT LIGHTNING GENERATOR
FROM "LIGHTNING"–POWER PLANT ENGINEERING, APRIL '29

Figure 2

A portable cathode ray oscillograph of the Dufour type, developed by General Electric, made possible the measurement of the wave shapes of actual lightning.

In order to make proper use of the oscillograph, it was necessary to devise a means of establishing the cathode beam, and the sweeping circuit, and to have a complete setup connected to the line as the lightning wave reached it. The complete operation, with the "switching circuit" developed, takes one microsecond. Even with such a small time, part of the wave front would be lost if special means were not taken to prevent it. One method of doing this would be to sidetrack the wave around a loop 1,000 feet long, requiring one microsecond to travel it, and take it coming back. Usually such means are not necessary.

The actuation of the oscillograph is accomplished by means of spark switches controlled by the lightning surge, and connections are made to the line by an insulator potentiometer. Measurements are made on short horizontal antennae and on actual transmission lines.

The antennae consisted of three parallel wires 120 feet long, and forty feet above the ground. The wires were grounded through 2megohm resistors, and connections were made as indicated in Figure 3. With this arrangement, the lines assume a potential opposite to that of the cloud when the discharge takes place. Since

the charge cannot move along the line because of its shortness, but must be dissipated by leakage, the voltage of the conductors rises at a rate and to a magnitude dependent on the collapse of the cloud field. The time for the wave to reach its maximum potential is a measure of the time required for the cloud to discharge. Actual oscillograms show that wave fronts are of the order of one microsecond. Such wave measurements, indicative of cloud discharges, are exceedingly helpful in determining the shape of surges on a transmission line.

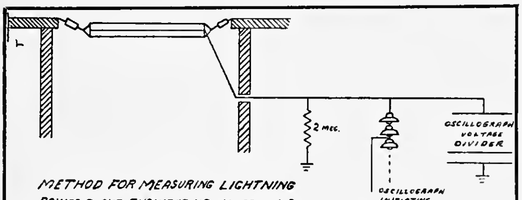


Figure 3

One wave on a 220 kv line reached a maximum in five microseconds, declined to one half value in 20 microseconds and reached zero in 40. The distance lightning can travel at high voltage on a transmission line is given by the following table.

Lightning in Kilovolts	Distance of Travel to Reduce to 0.5 Voltage	Distance of Travel to Reduce to 0.8 Voltage
4000	1.5 Miles	0.4 Miles
3000	2.1	0.5
2000	3.0	0.7
1000	6.3	1.6

The constantly increasing demands for uninterrupted service in transmission lines, has focused attention on the most disturbing factor—lightning. Progress had been hindered by the lack of suitable measuring instruments, but within the last few years, numerous instruments have been designed, and much information concerning lightning has been gathered.

Such instruments must be of automatic registration due to the uncertainty of times of occurrence of storms. They must record within microseconds, and because of the short time element involved, moving parts must of necessity be barred. The instruments described in the following pages therefore depend for their operation on rather unusual electrical principles.

The *surge voltage recorder* is built in two types: the moving film, and the stationary film types. Both use the Lichtenberg figure method of registration of crest surge voltage. The electrodes are connected in parallel, so the registration of each surge voltage, regardless of polarity, may be made with both positive and negative Lichtenberg figures.

The *moving film type* of instrument has an insulating box containing the clock mechanism and a compartment for the photographic film, which is driven at the rate of one half inch per hour. Time markings are put on the film through the use of engraved numbers filled with radioactive material. The connection of the surge voltage recorder to the transmission line is made through very low capacitance by

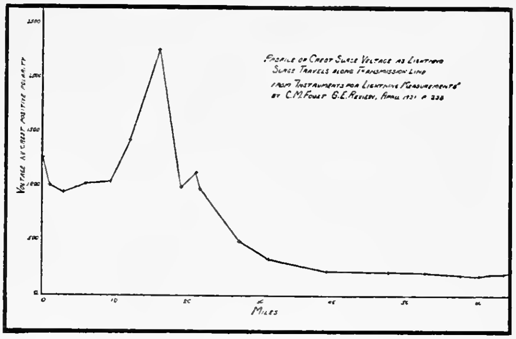
means of an insulator string voltage divider with grading shields.

A thorough study of surge voltage on transmission lines necessitates the installation of a number of recorders spaced along the line at intervals of several miles between each two. Such an arrangement will furnish a profile such as is shown in the graph; from such profiles may be calculated an attenuation curve of the surge as it travels from the point of stroke. A great amount of data has been collected, and an empirical formula has resulted.

$$e = \frac{E_o}{ksE_o + I}$$

where e is voltage in kv at distance s from origin, E_0 is crest voltage at origin of surge, k is a factor depending on the particular and ranging from .0004 to .00006, and s is the distance in miles from the origin. The formula has been checked by applying surges from artificial lightning generators, and the agreement is within the limits of accuracy of the testing equipment.

The *stationary film type* surge voltage recorder is a smaller and lower cost instrument, and is designed for the same field as the moving film type. Two circular films, four inches in diameter, are placed one in each side of the insulating box. The top film is in contact with the directly connected electrode, and the bottom one is in contact with the reversed polarity electrode. As in the moving film type, both positive and negative Lichtenberg figures are obtained with each



Lightning stroke voltage surge graph.

surge. Each film box has a serial number engraved on it, and it is filled with some radio-active material, so a number is marked on each film exposed.

Laboratory experience with lightning generators early demonstrated the fact that the time element or the wave shape of the surge had an important bearing on insulation failure. So, in addition to measurements of surge voltage amplitude, the determination of wave shape became necessary. The *cathode ray oscillograph* is used because the time elements involved are of the order of microseconds. The fact that the electrons composing the cathode ray stream can be deflected by voltage applied to small deflection plates, simplified the application of the oscillograph.

A connection to the line through a low capacitance gives sufficient energy for a full scale deflection, and the arrangement is made safe by using insulators similar to those used in ordinary transmission line insulation.

The latest arrangement of oscillographs use two of them in circuit. Through sensitive tripping gaps, the

Rating of Line KV. Phase Voltage	Number of Insulating Units	Voltage Divider Ratio
33	3	15
44	5	20
66	7	26
88	10	36
110	12	45
132	14	60

first oscillograph begins to trace the wave shape 1/4 to 1/2 microsecond after the incoming wave arrives on the line. This oscillograph records the lightning on a fast time axis of fifty microseconds. The second oscillograph begins to trace the surge one to two microseconds after the first one starts, and records the remaining portion of the surge and later, the reflections as it returns.

Specimens of oscillograms have added materially to our knowledge of wave shapes of lightning surges.

Soon after the first measurements of voltage amplitude and wave shape were made, an instrument was found to be necessary that would differentiate between a direct stroke and an induced surge. The *lightning stroke recorder* was then developed. It consists of a porcelain base, a weatherproof metallic cover, and a light proof film packet. The base has an electrode connected to a supporting clamp, and the cover holds an electrode which is connected to a point some fifteen to thirty feet above the instrument. The film packet is between the electrodes.

A high current surge of 50,000 amperes or up for direct strokes, gives ample voltage across the fifteen to thirty feet bridged by the instrument leads to make a Lichtenberg photograph on the film. If the discharge strikes close to the transmission line, the voltage gradient first increases slowly, reaches a maximum, and then suddenly collapses in the time for the flash to bridge the last hundred feet or so of the gap. The latter time, or the wave front, depends on the driving power behind the flash, that is, the energy stored in the cloud field. An induced surge, such as described above, will not give a high enough current to make a picture.

A *surge indicator* gives an immediate indication of an insulator assembly flashover. The instrument, which consists of a metal housing, indicating target, a trip link which is easily broken, and a lead-in indicator, is connected across a tower arm which carries the flashover current from a particular insulator assembly.

The instrument operates as follows: when an insulator flashes over, the rush of discharge current flows through the tower arm, and then the surge indicator. The heavy current disrupts the frangible link, and the pressure of a spring forces the target into a visible position. A new trip link, which is easily and quickly inserted, resets the instrument. There are over fifteen hundred of these in use at the present time.

An important instrument which is not connected to a transmission line,

is the *lightning severity meter.* It consists of a camera containing photographic film, a glow lamp, and a short antenna. When the antenna is in the cloud field, it receives a charge that is proportional to the strength of the field. Then, when the stroke occurs, the field around the wire collapses, and the antenna charge passes through a glow tube. The proportional illumination received is recorded on the film, and the depth of the light exposure on the film is a measure of the integrated field intensity over the period of the time of exposure.

Each of the above instruments is valuable in its particular field, and through the continued use of them, valuable data applying to the ultimate solution of the lightning problem can be obtained.

Some interesting data taken from "Lightning" in "Power Plant Engineering," vol. 33, p. 416, are given below.

Lightning:

voltage . order of 100,000,000
current . order of 100,000 amperes
energy . order of 4 kilowatt hours
power . . order of 1,000,000,000,000 h.p.
time . . . order of a few microseconds

The total energy dissipated in the world by lightning is 1,200,000 kilowatts continuously. (Very approximate.)

Characteristics of lightning on lines: High voltage waves are effective for about twenty microsecs; low voltage waves are of much greater duration, voltage either by induction or by direct stroke; current in line from 2,000 to 5,000 amperes; voltage nonoscillatory; voltage increases directly as height of line.

The Elimination and Control of Health Hazards in Industry

By ALEXANDER H. ZIMMERMAN

THE Industrial Hygiene problem confronting industry is twofold in that the health of both the worker and industries' neighbors must be safeguarded. It is not only essential that harmful fumes, gases, dusts, etc., arising from industrial processes be removed from the space in which the worker toils, but it is just as important to collect and dispose of these materials after they are removed from the factories, so that health hazards and nuisances to the surrounding neighborhood are eliminated.

Very often valuable dusts and fumes are allowed to escape to the atmosphere, when they can be economically collected in such a manner as to bring about a profit on the investment made in collecting equipment.

The prevention of industrial poisoning involves two essential methods of procedure. The first concerns the method of preventing unhealthful and poisonous air conditions and resolves itself into an engineering problem of controlling the degree of contamination, while the second is concerned with the personal care and health of the worker and is strictly a medical problem.

There is not only a fundamental physical and chemical difference between solids, liquids and gases, but there is even a more important physiological effect distinction, in that their mode of entrance is different. Solids and liquids usually enter the body by being swallowed. Sometimes fine particles, in the form of dust or fumes, are breathed in and reach the lungs, but the greater amount is caught in the saliva and swallowed, thus passing into the system by way of the digestive tract. Volatile substances, on the other hand, are inhaled and enter the respiratory tract. There are three portals of entry for industrial poisoning, namely, through the air, contact and food contamination.

From the respiration standpoint, gases and volatile substances have been classified into four groups, asphyxiants, irritants, volatile drugs, and inorganic and organo-metallic substances. Representatives of each of these groups are respectively: Nitrous Oxide which under all normal tem-

perature conditions is a gas; Sulphuric Acid which under normal conditions is a liquid but when heated to high temperatures gives off gas that is extremely corrosive, Methyl Alcohol, normally a liquid but which passes easily into the gaseous state at a relatively low temperature; and Hydrogen Sulfide.

The most important mode of entrance for industrial poisoning is through the air which is breathed in and which carries not only toxic gases, but dust and fumes. Dust and fumes that are breathed in, will in part reach the lungs, but very often the greatest amount is caught in the saliva and swallowed. The nature of the poisoning, however, differs according to whether the poison has reached the stomach or passes directly to the lungs. Dust may be classified into three groups—Poisonous, Fibrosis Producing, and Non Fibrosis Producing.

A second mode of entrance for industrial poison is contact, or through the skin. There are a large number of compounds used in industry which fall into this class and which require the workers to use protective measures. Nitrobenzene, picric acid, phenol, caustic powders, cyanides, acids, etc., fall into this group.

The third mode of entrance is through food contamination, although listed last in relative importance, must be seriously considered. This mode furnishes a means of direct ingestion through the mouth by conveying the poison to the mouth from smeared hands which serve to contaminate food or tobacco, or through some implement of work.

Accidental formation of gases in industry is a possible means of poisoning that is often unthought of. Under certain conditions occurring during a process, harmful gases may be formed which are not normally encountered. Very often these gases are undetected until they have taken effect on the exposed men, and then sometimes the real cause of poisoning is unsuspected. For example, the use of carbon tetrachloride as a fire extinguisher in an atmosphere poor in oxygen, often results in the formation of phosgene, a very poisonous gas. This same fluid is often used in the cleaning of metallic parts, and very often this process is carried on while the parts are yet warm and in work spaces poorly ventilated. The result is the production of the deadly gas, phosgene.

Protection along these lines lies mainly in the recognition of the possibility of the formation of such gases and vigilance to guard against it.

A very important means of reducing industrial poisoning is the substitution of non-hazardous for hazardous chemicals. Lead paints, for instance, have been a source of innumerable lead poisoning cases, and as a result, substitutes for lead have been devised. The two most important of these substitutes are lithophane and titanium oxide. Both are white pigments which make excellent and durable paint.

A most important mode of prevent-

ing industrial poisoning is the prevention of the escape into workrooms of gases, fumes, or dust from industrial processes. This method of prevention lies mainly along the lines of adequate and properly designed exhaust equipment. The harmful substance should be taken away from a point as close as is feasible to the source. Consideration should also be given to the natural movement of the materials, for if they are lighter than air, they can be exhausted laterally or vertically away from the source, but if they are heavier than air, a downdraft exhaust system is the most efficient.

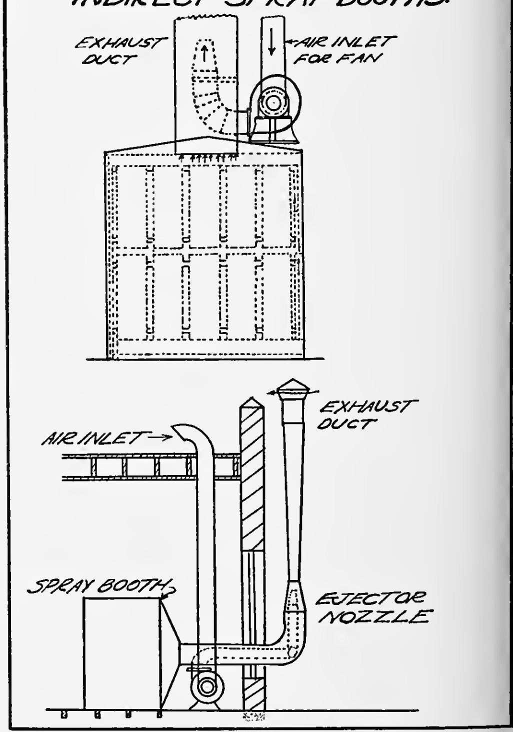
Natural ventilation cannot adequately remove such poisons as the spray of chromic acid produced during chromium plating, and forced vertical exhaust ventilation through hoods is ineffective and undesirable due to its drawing the spray past the face of the operator working over the tank. The most efficient method of removing such fumes is laterally across the tanks having marginal ducts along the sides and ends of the tanks. This type of system is rapidly coming into use for all types of plating in hot cyanide solutions.

The spray or air brush method of painting, lacquering, and varnishing is rapidly replacing the old brush method, and although the former presents certain hazards, it can be safely made use of if proper precautions are taken. Spraying is usually carried on in various designs of mechanical exhaust booths constructed of non-combustible material and open at one side only. There are two types of spray booth exhaust systems in use: the direct exhaust and the indirect exhaust. With either type, in order to insure a proper exhaust, an adequate fresh air supply must be admitted to the room from the outside.

Exhaust systems for dust removal must be designed so as to be adapted to the individual characteristics of the dust producing machines, and the type and physical characteristics of the material to be exhausted must also be considered.

There are some processes in which the escape of fumes, dust, etc., cannot be entirely prevented, and in many instances, these harmful materials can-

INDIRECT SPRAY BOOTHS



not be efficiently removed. It is therefore necessary that the workers individually wear efficient protective equipment such as respirators, gas masks, or hose masks.

The prevention of skin contact with harmful chemicals is very important. When handling such dangerous chemicals the worker should always wear gloves made of material capable of shielding the hands and arms in an efficient manner.

Very often workers labor in an atmosphere containing harmful dusts, such as arsenic, potassium, or sodium cyanide, etc., which are soluble in perspiration and which cause harmful irritant effects. In such cases the worker may be protected by smearing the exposed parts with a protective ointment, and lightly plugging the ears and nostrils with absorbent cotton. In addition, the men should be furnished with clean work clothes every day, and at the end of the day's work, the men should be required to take a shower bath.

Industry is centering more and more around densely populated areas and as a result, there arises the problem of preventing atmospheric pollution from the various industrial processes. Great strides are being made in this field and vast sums of money are being spent in research dealing with the collection of the various industrial air contaminating wastes.

Settling chambers are fairly effective for removing large dust particles and make use of the principle of having a chamber large enough in cross section to allow the velocity of the gases to be reduced to such a point as to allow the dust to settle out by gravity. Where large quantities of gas and dust are to be handled, the dust chambers must be so large that they are not economically or commercially feasible. In addition, these chambers cannot be installed on the suction side of high suction induced draft fans.

Dust traps are in reality settling chambers, varied in shape, and containing baffle plates, staggered on the inside for increasing the efficiencies of collection.

There are many types and designs of centrifugal collectors which are often referred to as "cyclones." The separation of dust from an air stream by centrifugal collectors is dependent upon projecting the particles tangentially out of the air stream. The effectiveness of these collectors varies directly as the specific weight of the dust, and as the square of the tangential velocity, and inversely as the radius of rotation. Cyclone collectors are not effective for very fine dust and often auxiliary collecting facilities must be used when the dust consists of a mixture of large and finely divided particles.

Scrubbers or washers make use of water or other liquids in which the dust is soluble, or where the dust will readily mix with the liquid used. This type of equipment is fairly efficient if the air is not too heavily dust-laden

and provided that the dust or gas, in which the air is carried, does not form corrosive solutions.

A collector effecting dust separation by passing the dust laden gases through a filtering medium, is usually referred to as the filter type. Cloth filters such as cotton and wool are chiefly used as filter mediums for dusts arising from industrial processes, and are made use of mainly in the bag form. Cloth filters clog easily, and therefore some means of shaking or dislodging the dust adhering to the cloth surface and enlodged in the mesh must be used. If the mesh becomes clogged, the resistance is considerably increased and as a result there is a corresponding increase in power consumption.

Cloth type filters cannot be used for hot gases, or where the gases contain a high moisture content conducive to clogging, or where the gases are corrosive. In order to overcome the temperature and corrosive difficulties, added cooling and neutralizing facilities can be used.

The electrostatic precipitation method is usually referred to as the cottrell system. It removes suspended solid or liquid particles from a gas system by producing an electrical charge upon the particles and then utilizing the pull of a powerful electrical field to cause them to travel to an oppositely charged surface to which they adhere.

The precipitator consists of a gas-tight chamber containing wire electrodes placed axially in a pipe, or suspended between plate surfaces placed in the gas stream and connected to a high potential line of from 50,000 to 75,000 volts A. C., which is rectified by a mechanical rectifier to supply unidirectional current to the precipitator electrodes. The discharge, taking place from the wire electrodes connected to the other side of the line, causes the suspended particles in the gas to become charged by absorption of ions from the ionized gas and the particles move toward the negatively charged plates upon which they deposit, being removed either by gravity or mechanical cleaners. The efficiency for removal is a function of the time and surface exposure of the gas stream to the electrical field, and is practically independent of the concentration of suspended material and gas temperature. High temperatures may be maintained, and with the use of proper materials corrosive materials may also be handled.

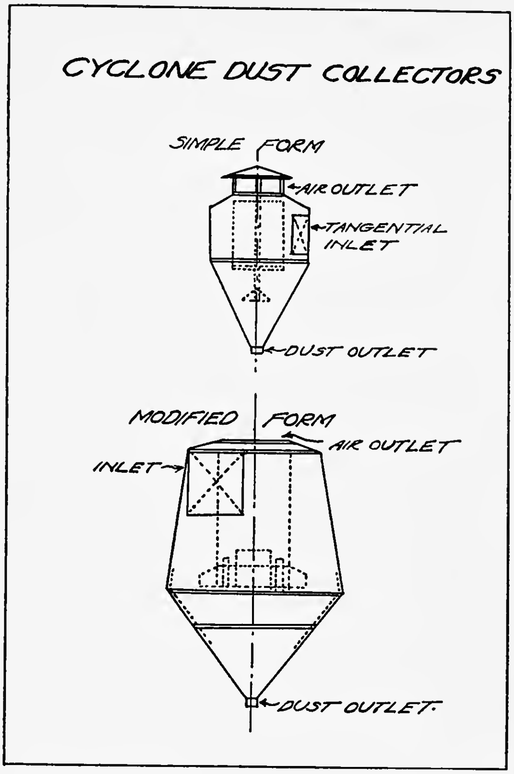
There are many varied industrial processes being carried on in Chicago and a large number of these processes were at one time, and still are in some instances, contributing to atmospheric pollution through their discharge of fumes, dust, etc. Those industries that are still contributing to atmospheric pollution are trying to solve their problems either on their own volition or, as in some cases, are being hard pressed by Health authorities.

The large number of successful dust and fume recovery systems, as installed

in Chicago, are based, in many instances, upon principles suggested by the Division of Ventilation and Industrial Sanitation of the Chicago Department of Health, and practically every method of dust and fume recovery has been employed. In some cases the recovery systems have not only abated the nuisance of atmospheric pollution, but have provided a source of revenue from the sale of the recovered materials.

Acids are used in a great many industrial processes and very often there is an emission of fumes which is not only detrimental to the health of the worker, but which also creates a neighborhood nuisance when discharged into the atmosphere. The problem of controlling the fumes is twofold. It is not only essential that adequate means be provided for taking the fumes out of the plant, but it is also necessary to be able to dispose of these fumes inasmuch as they would create a nuisance if discharged directly into the air.

There are various methods which may be used to dispose of these acid fumes and in processes where large volumes of fumes are given off, the fumes may either be condensed and the acid reclaimed, or the fumes may be neutralized with alkalis to form salts. In many instances enough acid cannot be economically reclaimed to pay for the cost of the reclaiming process and consequently in the majority of cases equipment is constructed, not with the idea of reclaiming the acids, but for the purpose of their disposition.



Often the acid is given off in the form of a fine spray. That is, hydrogen or steam is evolved in the form of fine bubbles which are coated with acid. These bubbles rise to the surface, burst, and in escaping to the atmosphere form the spray. In order to remove the acid, the electrical precipitation and the absorption tower methods can be used. The former is often more costly than the latter and is not used as much for small installations.

Architecture as a Profession

By WILLIAM F. KROL

AN ARCHITECT is properly called a professional man. He has nothing to sell except, what any other profession has, disinterested professional service. The qualifications of his profession are perhaps more diverse than those of any other profession. He must possess a good background of the liberal arts and of general culture. He must have a thorough acquaintance with the structure, strength, and durability of all the materials which go into the making of a building—the great variety of materials and equipment and the methods by which they are assembled by the various building trades into the completed structure. He must possess an instinctive feeling for design and a highly developed technical skill in construction. In addition to all this, he must be a business man, familiar with the various contractual and legal relationships occurring in the complex business of building.

It is obvious that such an equipment can only be secured by years of arduous study and training. It is therefore necessary for the young man who desires to practice architecture, to serve a somewhat lengthy apprenticeship as a draftsman working in the offices of established architects where he may have the opportunity to observe at first hand the conduct of the many and varied building operations.

One of the most prevalent misconceptions about the architect is that he is a maker of plans. He is no more a maker of plans than a physician is a producer of prescriptions or a lawyer a compiler of briefs. The making of plans is often the smallest and most insignificant part of the architect's work.

An architect is neither a building contractor nor a structural engineer. The building contractor is the one who takes the architect's drawings and specifications, provides the materials and equipment called for therein, and employs and directs the labor necessary. The structural engineer is the designer of structures, and works from the standpoint of producing a sound and safe construction. His position in the building field is that of consultant for the economical solution of the more complicated structural problems.

The architect is the one man in the building field who weighs the various factors that enter into a building project and coordinates and combines

them so that they will be held in proper equilibrium. The question of "the relationship between the building and the human beings who are to use it and for whom it is to be built," is uppermost in his mind.

A high standard of ethics must be conformed with by the architect. His integrity must be beyond reproach; his interests must be identified with those of his clients; and his compensation is only the fee paid him by his client. He cannot accept any commissions or favors from contractors or material dealers. He must do nothing to give an impression that he is partial to this contractor or to that material.

The Architect's Ability to Plan An architect gains specialized knowledge on the subject of planning because he studies the needs of all types of buildings and considers the ways in which these buildings are used by the people occupying them. As a result, he knows how best to apportion the available space in a building between its different parts, so that each division and room will be adequate in size and convenient in shape. He knows how to arrange the different parts so that they can be used most readily and effectively and so that each occupies the most advantageous part of the entire scheme in relation to the others.

The point of economy is of much importance. Every square foot of floor area is used to greatest advantage. The architect plans to get the maximum accommodations in a given total area.

It will be well to realize the fact that a client can tell the architect how large a building and what quality he wants, allowing him to ascertain what it will cost; or else, bind him as to the quality and the cost, allowing him to tell his client how much building he can secure for that amount; or, again, he can give the architect the size and the cost, and have the architect tell him what quality he can obtain. Manifestly, it is not necessary for the client to specify all three of these governing factors—size, quality, and cost—since any two of them will necessarily determine the third.

His Knowledge of Materials An architect must keep himself posted on the comparative merits of materials and equipment that go into the making of the buildings, and on the best methods used in putting materials together. Training on this begins as soon as he enters a drafting room as a beginner. Here he has an opportunity to see how the materials look before placed in a structure, how they look in structures where they are in use, and also how well they have lasted. He sees how the experienced men select and specify materials for buildings in the process of design. He watches construction and observes the best methods of putting materials in place. In time, he has the opportunity to check up on the wisdom of employing materials and methods used.

The architect's knowledge of good contractors who can be depended upon to do an honest job in the locality

where you are to build, puts him in a position to serve his client to an advantage in the selection of men who are to bid for the job. If the investor in a building follows the architect's advice on contractors, he avoids getting into difficulties and disputes over inferior workmanship and shoddy materials. It often happens that the architect, by selecting the contractor, saves the client more than the fee paid him.

Beauty in Design An essential item for the architect to consider is beauty. This ability to create beauty marks an architect out from all other individuals connected in the building industry. He is very often referred to as a creator of beauty. Not all architects possess this talent in superlative degree, but it is not hard to distinguish their work from that of the ordinary contractor.

From the time a young man begins his study of architecture, he is continually thinking in terms of balance, color harmony, light and shade, proportion, rhythm, symmetry, and texture. During school days and after, he places himself in an atmosphere of fine art and cultivates his acquaintance with the fine things of the past in architecture, painting, sculpture, literature, drama, and even music. All the arts are inextricably interwoven and the fundamental principles of beauty underlie them all.

Knowledge of Legal Requirements Another important study for the architect to know, and so give his client the benefit of it, is that of laws and regulations for buildings which legislation protects from loss and damage. There are many legal requirements that are to be considered before a building is completed. We have the state and municipal laws, which touch in almost the same manner upon a building project, the lien laws, insurance laws, and laws of contracts. There are the community building codes and zoning laws. There are laws for the maintenance of public safety and comfort, during and after erection. The federal patent laws which insure a patentee his royalties for his ideas must also be considered.

It is urgent to comply with all these laws when a building is being erected, and so avoid suits, condemnation proceedings, and even arrest.

Functions of an Architect The functions of an architect, generally speaking, are twofold. Through his ability as a diagnostician and through conferences with his client, he establishes in general terms the size, arrangement, and character of the building and has drawings prepared and brought up to the understanding of his client. Secondly, his work consists in refining this scheme after it is approved by the client and in having it executed.

When a client calls upon an architect, the former gives his idea as to the type of building he wants, where it is to be located, how many rooms he requires, what they are to be used for, how many people are to occupy the buildings, what style he prefers, and

how much money he has available—in short, everything he has in mind about the project. It being the architect's wish to give his client complete satisfaction, the architect goes into detail about even the most trivial matters. If anything the client mentions is inappropriate or undesirable, the architect tends to straighten this matter out, and if the client is wise, he will adhere to these explanations.

The architect will make many suggestions about the things the client has forgotten, but wishes to include in the building, in order to make it up to date and complete. He will talk over the site conditions, present and future land values, transportation facilities, surrounding property conditions, sewers, gas, water, heat, electricity, and other necessities.

After the preliminary studies—form of plans and perspective pencil or water color sketches—are presented to the client, he has something definite to look at and is able to visualize the completed building. The architect will then point out the advantages or disadvantages of this or that feature. Standard forms of agreement, between the architect and client, which the client probably signs at one of his early interviews, provide that preliminary studies can be modified at the request of the client until he is entirely satisfied. The preliminary design should be carefully considered so that everything is present that is desired.

When the preliminary designs are finally approved, the architect goes ahead with the final set of drawings and specifications upon which his client's contract with the builder is going to be based. They are important because of being the only means by which the contractor is given complete instructions. They must be complete, because they give complete information upon which to bid. Incomplete or self-contradictory documents tend to bring about confusion, misunderstanding, and waste of money.

The specifications are written to include verbal instructions not covered by the drawings and must be entirely exact. They must agree with the working drawings, and so are made at the same time the working drawings are in progress. They set forth requirements about the quality of materials used and the workmanship on them. In writing these specifications the architect must utilize all his knowledge of materials and construction.

When the completed drawings and specifications are approved by the client, the ordinary method of procedure for the architect is to invite several contractors to bid on the work, or he suggests a few reliable contractors to his client for approval. After the client and architect decide upon these, the client mentions, oftentimes, a few contractors he has in mind, and bids are requested. They are sent for by means of blue print copies and specifications. With these as a basis the contractors estimate what the cost including overhead and a percentage

of profit is to be, and present their bids in a sealed envelope on an appointed date.

After the contractor has been selected the architect draws up a properly worded legal construction contract between the client and the builder. It is the duty of the architect to see that his client and the builder understand all the terms of the contract, so that no disputes will arise because of ignorance of the terms. It is probable that, at this point, the architect will suggest that the contractor be placed under bond. This will cost the client a small percentage of the job, but it is well worth while, inasmuch as it insures the client against possible losses such, for example, as the contractor not carrying out all his obligations.

When this is completed, the architect files drawings with the building department of the local government, and a permit is issued. The contractor gets the materials and men, and the architect turns to the making of additional drawings of details. While the contract drawings include everything that is to go into the building, they are ordinarily made at such small scale that it is necessary for supplementary drawings of details to be prepared at a larger scale to give the contractor, sub-contractor, and their workmen a more exact picture of what is wanted. In the process of detailing the architect considers the best methods of assembling parts to avoid the evil effects of shrinking and swelling, easy motion of moving parts, water proof qualities, and so forth. In these drawings he gives particular attention to carved or modeled ornaments, which, when well designed, contribute to the beauty of the building. Sometimes the architect prepares, or has prepared, clay models, which can be duplicated by the craftsmen in whatever material required.

After the builder is supplied with everything needed, the architect, or a competent assistant, visits the work regularly while it is in progress, to exercise supervision. On the larger jobs, it is highly desirable to have continuous superintendence by a clerk of the works representing the architect, especially when the work is let only to sub-contractors, or in other words, a separate contract basis. On these visits of the architect, or his assistant, suggestions for minor adjustments are made, the desirability which may become apparent to his trained eye as the work takes shape. These slight changes do not involve extra cost. He will also insist, if necessary, that the work be properly carried out if there are any discrepancies.

During the execution of the work it becomes necessary to pay the contractor, at intervals agreed upon, for the performance of his part of the work. It is the architect's duty to issue certificates of payment assuring the client that a certain part of the work has been done satisfactorily and the payment, therefore, is justified and due. This is done by the architect upon application by the contractor, the architect

first satisfying himself that the amounts due are not excessive. These payments are arranged according to schedule submitted by contractor before the first payment is due.

Cost for Services There are a number of arrangements by which the architect establishes his fee and is paid. In some cases it is a fixed sum, in others, it is a certain percentage of the building's cost. The latter method is most common. It is not an ideal arrangement, inasmuch as it permits the suspicion that the architect may increase his own fee in a degree to which he persuades his client to spend money on the project. It has a fairly sound basis on the other hand in the fact that generally the greater the cost of the building the greater the amount of work he has to do.

On a percentage basis, the architect's fee varies in accordance with the type of building. The small house entails an amount of work on the architect's part that is at least as much as, and sometimes more than, is required for a house of larger size and greater cost.

Selection of an Architect A person desiring to build selects an architect as he would any other professional man. This age is an age of specialization. A man whose practice, for the most part, consists of banks, may not be the one to choose for a country home. Many architects refuse work that they do not, for the most part, practice. If the project is large and complicated, it will probably be well to select an architect most familiar with that particular kind of work.

There are advantages of course, in the services of a nationally known architect; there are also advantages in the services of a young man whose reputation is as yet unmade. In a word, a client should exercise deliberate judgment and engage an able man. He cannot afford to do otherwise.

The Packard Diesel Aircraft Engine

By WILLIS G. BUEHNE

THE only American manufacturer of Diesel Aircraft Engines that has gained recognition to date is the Packard Motor Car Co. Their product is a 4 cycle, 9 cylinder, radial, air cooled engine with a government rating of 225 Horse Power at 1950 R.P.M. In developing a Diesel for aircraft use, there were two major problems to consider, weight reduction and high speed operation. Due to extremely high compression, Diesels had always been massive in design and slow in speed, being used for marine and stationary power.

Weight reduction was accomplished by an intense simplification of design. A single valve arrangement automatically halved the valve mechanism; since only air is drawn into the cylinder on the intake stroke, only one valve was necessary for intake and exhaust. Ordinarily, in a radial engine, each cylinder is bolted to the crank case so that, with this arrangement, the tensile stresses resulting from explosion in the cylinders, are carried by the crank case, requiring fairly heavy construction. With a Diesel this construction would be much too heavy for aviation purposes. Consequently, in the Packard engine, two steel alloy hoops fit over the cylinder flanges and hold them to the barrel type crank case, one being in front and one in back. They are contracted by sturdy turnbuckles so that an initial stress, far exceeding the operating stress, is set up in these hoops. At no time is it possible to transfer any tensile loads from the cylinders to the crank case, thus permitting a very light construction. Since the maximum pressures in a Diesel are about ten times greater than the average, the moving parts would have to be ten times stronger than those necessary to resist the average pressures, were it not for the fact that steps were taken to cushion these parts from shock loads. The counter weights and propeller are both flexibly mounted on the shaft, so that when peak pressures occur, there is a cushion between the shaft and those parts that have the greatest flywheel effect. Advantage is taken of the fact that peak pressures exist only for a very short time during the cycle. These steps toward weight economy enabled the Packard Co. to bring the weight of their engines down to a practical figure.

To obtain high speed it was necessary to have complete fuel combustion

in a very short time. In any 4 cycle Diesel engine, only air is taken into the cylinder on the intake stroke; on the return stroke the valve is closed and this air is compressed enough to raise its temperature above that of the burning point of the fuel. For fuel oil at this pressure, the temperature is about 1000°F. which requires a compression ratio of about 16 to 1. The fuel is injected at about 40° before top dead center to allow for ignition lag, so that full power is obtained from the fuel ignition at 2 or 3 degrees after top center, and the piston is driven down for the power stroke. Exhaust begins at about 45° before crank dead center, and the gases are forced out on the next forward stroke, completing the cycle. This allows a maximum of ½ revolution in which to burn completely the fuel injected. With an engine making 1950 R.P.M. the maximum time for combustion is about .015 sec., the actual probably being nearer .0075 sec.

In order to burn completely the fuel oil in this time it must be finely atomized and thoroughly mixed with oxygen. By means of a venturi shaped manifold leading to the valve, the incoming air was given a very high velocity, and by placing the valve at the edge of the cylinder the air was given a whirling motion in the cylinder, lasting throughout compression and insuring a complete mixture with the injected fuel. The fuel is finely atomized by a carefully constructed nozzle unit which is an integral part of the fuel pump, a design feature which deserves special consideration.

The most important part of any Diesel engine is the fuel injection apparatus. Heavy duty stationary and marine Diesels of 1000 H. P. or over, use compressed air to spray the fuel into the cylinder. Smaller Diesels use the solid injection for which there are two methods: either a multiple pump unit forcing the fuel at high pressure through tubing to each cylinder, or a combination pump and nozzle attached to each cylinder. The latter method does away with all high pressure tubing which cannot be used on high speed engines due to enormous pressure surges interfering with correct timing, so therefore this method is used on the Packard Diesel.

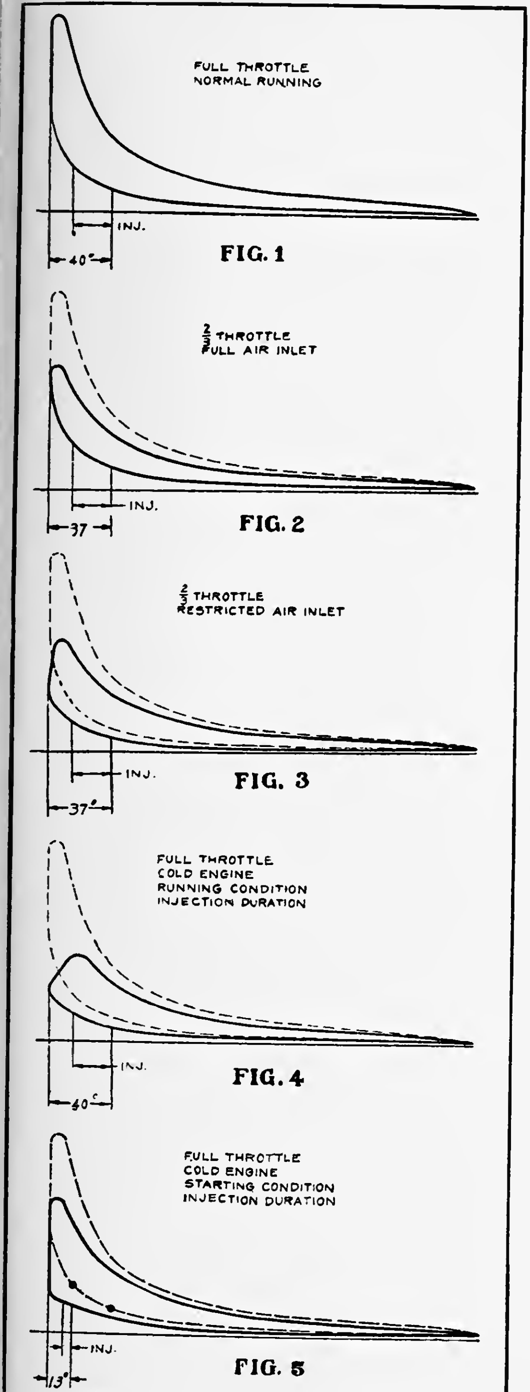
The fuel pump body consists of an alloy steel forging, machined all over, and fitted with a bronze cylinder which is pressed in place, after which the cylinder bore is finished by special methods developed to secure the extreme accuracy necessary. The pump plunger is attached by a rod to a cross head which, in turn, is fastened to a tappet rod, resembling a miniature steam engine layout. A small slot in the cylinder serves as the fuel inlet, so that, as the plunger travels over this inlet, the oil is trapped in the pump body, forced through a check valve, and out through the nozzle. The check valve prevents any explosion gases from backing into the pump. The amount of fuel injected into the cylinder depends upon the travel of

the plunger above the inlet, the plunger being controlled by a throttle lever in the pilot's cabin through a linkage. The linkage acts as follows: the loose end of the tappet rod has a ball tip that slides in a grooved rocker lever which is pivoted at one end. The rocker lever is operated by a four-lobed cam which travels ⅛ engine speed in reverse rotation to that of the crank shaft. Since the rocker lever is pivoted at one end, the farther away from the pivot the tappet rod end is placed in the groove, the farther the plunger will travel. As the stroke diminishes, injection starts later and the duration becomes shorter. At idling speed, the stroke is about 1/3 full stroke, injection starting 10° later, and is of about ½ the duration. The position of the tappet rod end in the groove is governed by a control ring to which the nine tappets are fastened, and which, in turn, is operated by the pilot's throttle lever.

The nozzle body is also an alloy forging, screwed to the pump body, and is formed with a two bolt flange which constitutes the means of attachment to the cylinder. The nozzle assembly is an independent unit which is screwed into the nozzle body; it consists of a flared end nozzle into which is seated a small poppet valve fitted with a compression spring so arranged as to hold the valve against an adjustable screw at the rear of the nozzle body. The valve is adjusted to be off its seat a few thousandths of an inch, an arrangement insuring excellent atomization for starting and running.

The power of the engine is determined by the amount of fuel injected, the amount of air present, the thermodynamic losses, and the mechanical losses. Fig. 1 is a full throttle card at rated speed. It is possible to throttle the fuel 2/3 with full air inlet to obtain the card shown in Fig. 2, or both air and fuel 2/3 with a considerable loss of efficiency as shown in Fig. 3. When the engine operates at a slow speed, especially at starting, a new form of card appears as in Fig. 4.

The starting processes on an aircraft Diesel are necessarily different from the running processes, as can easily be seen from the following discussion. While cranking, the cylinder is cold and the speed of rotation is slow, so that much heat has been lost to the cylinder walls by the time regular injection begins. Also, at the starting speed of 100 R.P.M. the duration of injection would be 20 times longer than at 2000 R.P.M., affecting proper atomization of the fuel. This condition of a poorly atomized fuel being injected into a cold cylinder is shown in Fig. 4, as producing slow and incomplete burning. Fig. 5, shows the same compression curve as Fig. 4 but a later point and higher pressure, at the point of injection, and a shorter duration of injection as is actually used. The short duration produces fine atomization thus shortening the ignition lag and producing a normal card where maximum pressure occurs just after top dead center. There are



Indicator cards of the Diesel under various conditions.

three cams in the engine, the air valve cam and running fuel injection cam which are attached to the same shaft and run 1/8 engine speed in reverse, and a starting cam which rotates with the crankshaft. Injection by the running cam occurs between 40° and 20°, and by the starting cam between 13° and 8° before top dead center. An inertia starter is used to turn the engine over, and the resistance of the engine to turning brings into play a mechanism which retards the running cam about 35°, putting the starting cam in the lead. The slipper on the rocker lever, being wide enough to span both cams, injection is automatically operated by the starting cam when cranking is begun, and the engine begins firing on the first revolution.

The air throttle is used for idling and gliding, functioning similar to the carburetor throttle valve on a gas engine. When the air throttle is used, it makes the engine do work to pull air in through the small opening and since the same valve is used for both inlet and exhaust, the engine must also do work to force out the exhaust gases. When the plane is near the field preparatory to making a landing, and starts the long glide to the ground, the pilot throttles down the engine, automatically bringing the air throttle into use. This brings the propeller R.P.M. from about 1000, where it is kept by the driving force of the air speed, down to about 600, making the propeller act as a brake, and enabling

the plane to land in a much smaller field than would otherwise be possible. The fact that the engine has to do extra work when idling also increases its idling stability. When the air throttle is used the supply of fuel to the engine is very small, so that clean and smokeless combustion is still obtained.

The main object of the preceding discussion was to show how the Packard Diesel was made as nearly like the conventional gasoline engine as possible in weight, size, speed, starting, throttle action, and maneuvering ability. There are several advantages that are inherent to the Diesel. From an aviation standpoint, the most important are: elimination of the fire hazard, reliability, perfect radio reception without shielding, superior altitude performance, utility of operation, and economy in fuel and service.

The most destructive fires occur just after a crash, when a broken fuel line pours gas over the hot exhaust manifold. Since the flash points of aviation gasolines are near zero, some being below zero, the ease with which a fire can be started is readily seen. A cool exhaust manifold contributes greatly to the Diesel's freedom from fires. A large supply of cool air is always entering the front of the manifold at each cylinder to dilute the exhaust to such an extent that the fuel will not ignite when poured directly on the manifold. In fact, fuel oil will extinguish a flame when poured on it, and will ignite only when finely atomized. Diesel engine records including those of the Packard experimental shop, where aircraft Diesel's have been operated for hundreds of hours, do not contain instances of any fires whatever. The introduction of a fuel which will deliver more power than gasoline and at the same time suppress the fire menace to pilots and passengers should find a welcome place in aviation.

Increased reliability and better radio reception are both due to the elimination of electrical ignition and delicate carburetion systems.

The low fuel consumption inherent with the Diesel cycle, plus the lower cost of fuel, makes possible greater economy of operation than with a gas engine. The cost of fuel oil is about ¼ that of aircraft gasoline and further, a gallon of fuel oil will power a plane 1/5 again as far as a gallon of gas.

From the military standpoint, altitude performance is an important item. The table shows the data of a recent test flight in which the Diesel was superior in speed, rate of climb, and height attained when matched with an equal powered gas engine, for the same type of plane. A later test showed that a 350 H. P. gas engine was needed to duplicate the performance of the Diesel at 20,000 feet. The different performances of the two types as they gain altitude lies in the fact that the gas engine depends on a 15:1 ratio of air to gas mixture for best power while the Diesel depends on this 15:1 ratio for clean burning of the fuel. When the gas engine plane rises into thinner air this ratio is de-

The Packard Diesel-engined plane:

	Standard: Altitude:	Level Speed MPH	Level R.P.M.	Climb Speed MPH	Climb R.P.M.	Climb Rate Ft. Min.	Climb Time Min.
	0	116.5	1980	77	1750	730	0
	5000	118.4	2010	79	1795	676	7.06
	8000	118.6	2015	80	1820	617	11.69
	10000	118.0	2010	80.5	1830	567	15.06
	15000	110.6	1950	82	1830	390	25.47
Serv. Ceiling	19250	92.6	1810	82.3	1775	100	42.90
Abs. Ceiling	20000	82.0	1750	82	1750	0	

The gasoline-engined plane:

	Standard: Altitude:	Level Speed MPH	Level R.P.M.	Climb Speed MPH	Climb R.P.M.	Climb Rate Ft. Min.	Climb Time Min.
	0	103.2	1990	61.2	1790	635	0
	5000	99.4	1970	63.4	1785	412	9.7
	10000	91.3	1905	65.0	1775	190	27.1
Serv. Ceiling	12000	85.7	1855	65.0	1765	100	100
Abs. Ceiling	14270	64.0	1745	64.0	1745	0	

Performance data of the two planes in the tests described here

stroyed and power drops off rapidly while for the Diesel there is excess oxygen in the air up to 8000 feet, so that power remains the same up to this point and speed increases due to decreased air resistance. After passing 8000 feet power drops off less rapidly than with the gas engine.

Since the aircraft Diesel is still in its infancy of development and yet can boast of so many advantages, we can realize the tremendous possibilities of this engine when it has reached that stage of perfection that the gasoline engine has. The adaptability of the Diesel to the two stroke cycle makes possible the development of high powered Diesels for large planes whereby one engine properly placed will give better performance than by placing two or more engines on the wings, as is done today. Taken all in all, the future of the Diesel aircraft seems bright, for in these days anything that is for economy stands in favor.

THE TECHNICAL BOOKSHELF

REVIEW OF NEW BOOKS OF ENGINEERING AND SCIENCE

Noise and Vibration Engineering

By Stephen E. Slocum, Ph.D.

(D. Van Nostrand Co. N.Y.C., $2.75)

"FEW phenomena are more vexatious and at the same time more baffling than vibration. It has long been recognized by engineers as a powerful, though little understood force, and structures have been reinforced against failure from abnormal stresses resulting from it. Little attention has been paid, however, to the aesthetic or social and economic aspects of vibration. Only recently has popular opinion risen in revolt against unnecessary noises and vibration.

"To the engineer and civic worker who has been called to cope with this problem, this book should prove helpful. It presents practical solutions for vibration insulation of structures and machinery in addition to a comparative study of commercial vibration dampers and a mathematical analysis of the fundamental relations which characterize simple vibration.

"This book is a pioneer work on the subject of vibration and its various aspects in engineering, commercial, industrial, and civic lines. It presents a practical rather than a theoretical treatment of this important subject, and one of its purposes is to blaze a trail into a new field of no noise and vibration enginering.

Air Conditioning Engineers' Handbook

E. V. Hill, Editor

(Aerologist Publishing Co., $5.00)

AMONG many recently published books in the field of heating and ventilating the "Air Conditioning Handbook" offers to the reader a study of this subject that is notable for its completeness and simple style. It comes bound in a loose-leaf notebook cover with provisions for the removal and insertion of separate sections as they are introduced by the publishers.

The opening section answers the question, "What is Air Conditioning?" There is an analysis of the methods and equipment employed in the five systems of Air Conditioning now used.

The aerologist works with the Psychometric chart much as the steam power engineer might the Molier chart. A detailed description of the chart, its physical meanings, and its use comprise Section Two.

William Goodman, of the class of '24 has compiled the section on the

rinciple fundamentals, calculation iethods, and mathematical expression f the problems of air conditioning. Heat Ratio," by passed air, refrigera-on capacity, limitations of dehumidi-/ing and cooling with saturated air, re worked out completely.

Refrigeration designs and plants for ooling of air supply is next taken up. rof. Davies of the department of ex-erimental engineering here at Ar-iour is the author of a section en-tled "The Anemometer." His work based on research conducted in the boratories of the Institute. A com-lete treatment of the use of this in-rument for flow measurement and ie method of making a transverse test omprise the material of his work.

Pitot tubes and manometers are ext in a section that includes a de-ription, the methods of use, and the andard Code for testing fans.

For a final chapter the editor, E. . Hill gives a discussion of the ap-lication of the principles of air con-tioning to the small home. Layouts the steam, hot water, and warm-air eating systems; insulation calula-on, and data; heating with stored ectricity; ventilation of the home; entilation through kitchen and at-c; and a layout for mechanical re-igeration make up the subject-matter the closing chapter.

The authors and the editor of Air onditioning Engineers' handbook re-ive the earnest commendation of the *ookshelf* for having produced a early and simply written handbook.

Balancing of Internal Combustion Engines

By Arnold S. Lack

(Armour Institute of Technology)

THIS volume, in thesis form, has been recently received by the Armour Library. It presents a lengthy series of investigations into all the many influences affecting proper balance of both gasoline and Diesel engines. The subject has been treated in a theoretical and practical way, a large amount of data is included, and the material is such as to be valuable for designers and engineers interested in this field.

This work treats of the general determination of the behavior of masses in motion, and investigates the balancing of reciprocating engines of all types of cylinder arrangement.

The author is an authority in this field, being at present Consulting Engineer for Fairbanks, Morse and Co.

American Public Buildings of Today

Edited by R. W. Sexton

(Architectural Book Co., $12.50)

PREFACED to this collection of beautiful architectural photographs we find a foreword by William Adams Delano, one of the best known architects and architectural writers in America to-day. Mr. Delano, in discussing the modern trend in architecture as applied to public buildings, brings out a few points which will

make us stop for a moment in our constant striving for "functionalism" and think. He makes one feel that the classical styles still have a place in our modern work and this contention is further borne out by the great number of beautiful buildings with a classical feeling that are included among the illustrations.

The plates cover city and town halls, court houses, fire stations, museums, public libraries, and park buildings and each section is introduced by a short article discussing that phase of the planning of public buildings. There are illustrations of examples from all sections of the country and of a large number of different sized buildings from such as the Cook County Criminal Court House, the Field Museum and the Pennsylvania Museum of Fine Arts in Philadelphia, Pennsylvania, down to a very small and unpretentious Memorial Auditorium and City Hall at East Point, Georgia. There is usually a plan of each example together with several exterior views and often some interior views.

Two very beautiful and, to us, novel examples are the Municipal Building at Opa Locka, Florida, and the Santa Barbara Court House at Santa Barbara, California. While both buildings are built around large open courts, the Florida structure was inspired by the old Persian Mosques and with its minarets and bulbous domes, seems to have been lifted out of Arabian Nights. On the other hand the California court house is beautiful example of the old Spanis Mission style applied to moder buildings.

Aircraft Radio

By Myron F. Eddy

(Ronald Press, $3.60)

THIS book was written for th guidance of aviation students in familiarizing themselves with th theory and operation of radio equip ment as encountered in the aeronau tical industry. It covers the recent de velopments in the direction of aeria traffic, in the distribution of weathe information and the general function ing of the "nerve system" of aviation

Lieutenant Eddy, retired from th U. S. Navy, has taught this subject in naval and commercial aviation school for several years. "Aircraft Radio is the only unified compilation of ma terial which up to now had to be gath ered from a large number of sources.

The first few chapters, covering th fundamentals of electricity and radio are for the average aviation studen who has had a little previous instruc tion. The remainder of the book deals with practical installations of re ceivers and transmitters in planes and airports, giving circuit diagrams and relative merits of those most com monly used; it describes in detail th radiobeacon, marker, and direction finding systems. The theory, installa tion, and operation of many new de

ices, which have recently appeared in ircraft radio, and on which informa-ion is difficult to obtain, have been ollected and presented in detail.

U. S. Statutes and regulations relat-ng to the operation of radio equip-nent on planes and airports are listed, nd the ordinary routine and proced-re outlined.

Snow Crystals

By W. A. Bentley & W. J. Humphries

(McGraw-Hill, $8.00)

"LET the snow fall, since we cannot prevent it," might be the cry f traction companies during a rag-ng Chicago storm. Yet this blanket f white, which can effectively stop he business of a city for a day, is com-osed of fabulous millions of intricate rystaline flakes. Each one is so beau-fully shaped and so symetrically per-ect that it gives the appearance of eing the creation of some artist whose riginality was infinite.

Mr. W. A. Bentley, a New Eng-nder, has developed a hobby of hotographing and classifying snow rystals. His technique is so perfect at he has had many of his pictures ublished in scientific publications. Others have been used in illustrated lectures. Fifty-three hundred have been made during a period of forty years and of these, 2000 have been selected for the publication of "Snow Crystals." It is the only book of its kind.

A short introduction giving the scientific theories of ice crystallography, an explanation of the microphotograph process, and a description of the various forms of crystals, occupy the first 21 pages. Following this are 200 plates of the crystals.

Generally ice crystals have a hexagonal form, either consisting of six points or six sides. Occasionally the lines and contours on their surfaces form fantastic images of familiar or unexpected things: mariner's wheel, hippopotamous heads, helmets, or a breakfast table set for three. Seldom has science to deal with such aesthetic subject-matter.

Artists have often used in their work the designs these crystals assume. They find in them a gracefulness which is rare elsewhere in nature.

Granted that one is charmed by beauty, and that one has fifteen minutes to spare, he will appreciate thumbing through this book. It is a rapsody of hexagons.

THE ARMOUR ENGINEER

Student Technical Publication of Armour Institute of Technology

MEMBER OF NATIONAL SCHOLASTIC PRESS ASSOCIATION

VOLUME XXIV | JANUARY, 1933 | NUMBER :

A Staff Policy

THE ARMOUR ENGINEER publishes articles of real value and of a wide scope of interest, these articles being in the main written by students, faculty members and alumni, as befits an undergraduate technical publication. THE ENGINEER has made no basic changes in its policy as regards feature articles. Articles are welcomed by students, faculty members and alumni in all branches of engineering, science and architecture, and are considered for publication only in the light of what each offers of rea interest and value to the readers. I is very true that the experience anc confidence gained by a student in th preparation and publication of ar article is of the utmost value to tha student, but it is not the purpose o the staff to publish an inferior studen article, of no interest or value to th readers, which only aids that studen author in the manner just mentioned In the other extreme, while it is tru that faculty and alumni articles ar most authentic and of highest origina

alue, yet the staff will not present hese contributions to the exclusion of all student material. A fair nedian path is held, to the increased alue and development of the magazine.

A Thin Skin

INHERENT, to a large extent, in the youth of today is a lack of nitiative. The average young man vants to be led into action rather than o lead; any tendency toward original hinking makes little headway, and if here is original thought, it usually ies dormant and unexpressed in the nind of the originator.

A successful engineer is not one vho must be led, forced, or cajoled nto accomplishing acts; he is one vho sees his future actions clearly, nd strives ahead, unafraid, toward he motivation of his ideas.

One of the greatest impediments to nitiative is the fear of failure. One vho is in dread of public scorn, one vho has not the courage to believe hat he is right and the rest of the vorld wrong until otherwise proven, s unfit for the engineering profession, a profession which, in the nature of itself, requires sound thinking, orceful action, and a personality impervious to the word "failure." "Our doubts are traitors, and make us lose he good we oft might win, by fearing o attempt."

THE GUEST EDITORIAL

Progress

OUTSTANDING among the many activities of the Development Committee of the Board of Trustees is the augmentation of the Board to thirty-three members. All of the members of the Board are leading figures in the industrial and commercial life of the Chicago area. We of the Institute, faculty, students, and alumni, expect from them the same thoughtful cooperation which they have used so successfully in their various businesses and industries. We do not lean upon them; we in turn shall coöperate with them by giving them our services as we have in the past. Every effort will be made to improve our student body, our curricula, and our faculty, but we shall do it cautiously. Armour is the result of almost forty years of careful, painful planning by men who gave their best efforts and even their lives to bring Armour Institute of Technology to its present level of excellence. God give us strength and wisdom that we may build for the future as effectively as we have done in the past.

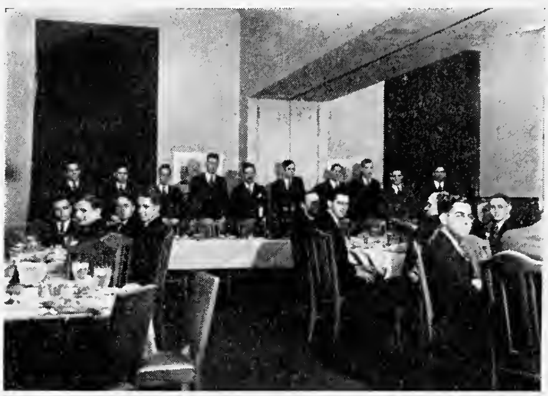
—JOHN C. PENN,
Dean of Engineering
Armour Institute of Technology.

THE COLLEGE CHRONICLE

NEWS OF THE HONORARY GROUPS AND DEPARTMENTAL SOCIETIE

Interhonorary Banquet

THIS annual dinner of the members of the various honorary groups at Armour was held on the evening of Dec. 16, at the Chicago Women's Club. Here the members of the various organizations had an opportunity to meet the leaders in the other branches of endeavor. Dean Heald acted as toastmaster to introduce the presidents of the various groups in order that their pledges might be introduced. Dean Penn gave an interesting discourse after which Mr. Perry Addleman of the Armour Development Committee was introduced as the guest speaker.



The Interhonorary Banquet

The speakers' table, left to right: Dufour, Clanton, Juvinall, Sorensen, Mr. Addleman, Dean Heald, Dean Penn, Beard, Paine, and Davies.

Pi Tau Sigma

AT THE annual smoker held at the Triangle House, the members of Pi Tau Sigma, honorary mechanical engineering fraternity, pledged several new members. These were three seniors and two juniors:

M. J. Erisman, '33.
W. C. Hoffman, '33.
R. E. Nelson, '33.
Earl Gosswiller, '34.
R. W. Suman, '34.

Tau Beta Pi

AT A banquet held at the Universit Club, Dec. 9, the following men wer initiated into th national al engineering hor orary fraternity Paul A. Carlstone M.E., '33.
Norman E. Co burn, C.E., '34.
Raymond J. Du four, M.E., '33.
Bradford Larson F.P.E., '33.
William W. Lange E.E., '33.
Bernhard H. E Loesche, C.E., '33
Stephen A. Vander poorten, F.P.E., '33.
Donald G. Wilson, E.E., '33.

In Oct., 1933, the national convention of Tau Beta Pi will be held in Chicago. The active chapter is busy planning for this great event.

Phi Lambda Upsilon

AT A recent smoker, Omicron Chapter of Phi Lambda Upsilon, honorary chemical society, pledged the following four men:

Vincent J. Galvani, '33.
K. Lewis Hackley, '33.
Walter G. Hollmann, '33.
Walter E. Gunderson, '34.

A high scholastic standing especially in chemistry is the primary basis for member-

ship. A secondary vote is taken on the candidate's other activities.

Professor Carpenter was the guest of the chapter at the Inter-honorary Banquet held December 16.

Scarab

SEVERAL honors were bestowed upon the Armour delegation at the Scarab National Convention held in St. Louis, Missouri.

Armour representatives secured the Convention for Chicago for the next year, and were honored in having T. H. Irion elected to the national office of Director of Activities. The Armour architectural honorary received additional distinction in the form of an Honorable Mention to G. W. Terp for his water colors exhibited in the Traveling Sketch Exhibit.

Salamander

THE pledgeship of the three men selected last October is now rapidly drawing to a close. These students have completed their required theses and will be initiated in the near future.

S. A. Vanderpoorten and H. J. Bannasch made a survey of the fire protection facilities of "A Century of Progress," while C. A. Cunningham wrote of "Fire Department Equipment."

Sphinx

THE honorary literary fraternity initiated, at a smoker early in this new year, the following men:

O. T. Barnett, Ch.E., '33.
E. L. Curran, F.P.E., '33.
E. E. Eberth, E.E., '33.
M. J. Erisman, M.E., '33.
E. P. Lomasney, Ch.E., '33.

Eta Kappa Nu

THE honorary electrical engineering fraternity has awarded a Standard Handbook for Electrical Engineers to Paul J. Thompson as first prize in the annual essay contest sponsored by the fraternity. His article, "Lightning, A Review of Progress Made in Its Study," proved most educational.

Several men have been chosen as pledges to the national fraternity. These are:

E. A. Dunham.
E. E. Eberth.
M. L. Priban.
P. J. Thompson.

Chi Epsilon

DECEMBER 15 marked the formal initiation of the following men into the local chapter of the honorary civil engineering fraternity:

J. T. Mauer, '33.
L. Gabriel, '33.
J. E. Schreiner, '34.

The paddling ceremonies, held at the Triangle house, took up the early part of the evening, and later the entire chapter went downtown and had dinner at the Blackhawk Grill.

Pi Nu Epsilon

THE members and pledges of Pi Nu Epsilon, honorary musical fraternity, performed a great deal of the work which helped to make the recent mid-winter concert such a success.

There are five men now wearing the scarlet and grey pledge ribbon. They are:

John L. Brenner, M.E., '34.
Gunnar F. Berglund, F.P.E., '33.
Clarence Clarkson, E.E., '34.
Milton A. Collick, E.E., '33.
Edward P. Reardon, E.E., '33.

American Institute of Chemical Engineers

STUDENT members of the Armour branch heard an educational talk presented by Mr. W. L. Kelly of the Chicago Moulded Products Co.

Dr. Clarence W. Muehlberger, consulting chemist of the Scientific Crime Detection Bureau of Northwestern University, and toxicologist for Cook County, explained various industrial poisons to an interested audience.

For possessing the highest scholastic standing in the freshman chemical class, Richard D. Armsbary was presented a medal by the fraternity. A smoker held during the holidays at the Phi Kappa Sigma house enlivened the spirits of all.

Fire Protection Engineering Society

AT THE last meeting of the Fire Protection Engineering Society, the members were very fortunate in having Mr. Snapp deliver a talk on farm insurance. On January 15, the society will have as its speaker, Mr. Hill, examiner for the Springfield Fire and Marine Insurance Co. He will talk on the underwriting of sprinklered risks, a feature of great importance to all men interested in fire insurance.

American Institute of Electrical Engineers

THE members of the Armour Branch were grateful indeed to Mr. Aubuchon of the American Telephone and Telegraph Company for his address on the "Use of Carrier Currents." In his talk Mr. Aubuchon outlined the various methods of using carrier waves that have been employed in telephone work. The system is used quite extensively in long distance transmission.

Western Society of Engineers

MR. A. W. CONSOER, a prominent consulting engineer, was the guest speaker of the Armour branch at a recent meeting. His talk dealt mainly on the various fields now opening up to the civil engineer. One particular phase discussed was the advantages an engineer may obtain in the field of highway transportation. Other opportunities mentioned were city managerships, tax adjustments, appraisal making, and sewage disposal.

The talk showed the audience the value of foresight in picking a field in which to specialize.

New acquaintances were quickly formed and friendships renewed at the smoker held December 14th, at the Triangle House. A play presented by the Chi Epsilon pledges furnished further entertainment to make the evening a success.

American Society of Mechanical Engineers

FOLLOWING the new policy initiated by the local branch, the members of the society have been keenly awaiting the future talks to be presented by the various members on topics of technical interest.

In the speeches delivered by R. J. Dufour and H. J. Monger, the intricacies of "Pipes and Tubing," and of "The Linotype" were disclosed.

A very interesting discussion took place recently relating to the modification of the present program of shop work. Various suggestions and plans were presented. The plan which is in operation at Harvard found favor among many. This system is built on the lines of a demonstration course in which the instructor makes evident the facts of shop work. Further discussions are planned which are intended to improve the members' linguistic abilities.

TECHNICAL ABSTRACTS

CONDENSATIONS OF LEADING ARTICLES IN THE TECHNICAL PERIODICALS WITH PERMISSION OF AUTHORS AND PUBLISHERS

Engineering Uses for Geophysics

By Sherwin F. Kelly

(From Civil Engineering, Oct., 1932)

THE knowledge of the depth of soil that covers bed rock is useful to the highway and railroad engineer, who must calculate the cost of excavating rock and soil in cuts along the right-of-way. To the bridge or dam engineer, a sure knowledge of bedrock contours is a prerequisite to the design of his foundations. An electrical method of geophysical exploration used in recent years both in this country and abroad will now be explained.

Fundamentally, electrical methods of geophysical exploration depend on the fact that different types of bed rock possess measurably different electrical resistivities. This is due to the fact that all rocks contain a certain amount of moisture, which in turn is conductive because of the dissolved salts. Thus granite and igneous rocks are drier and more compact than sedimentary formations and hence more resistant.

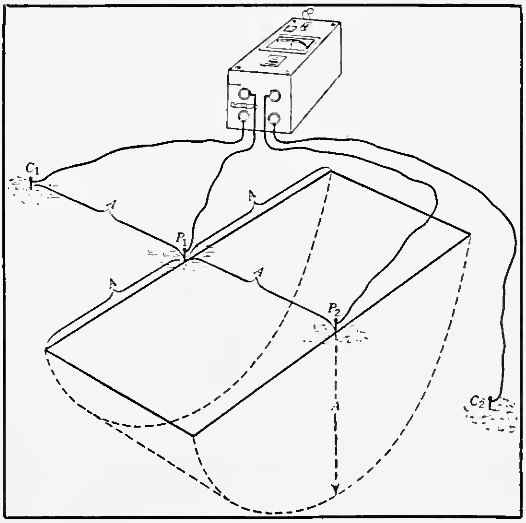
Measurements can most easily be made by the system devised by Frank Wenner of the U. S. Bureau of Standards. A current of fifty volts is passed through the ground between two metallic stakes driven into the earth and its amperage measured. At the same time a drop in potential is observed across two intermediate stakes driven into the ground between the first two. This voltage drop divided by the measured amperage gives the resistance in ohms between the two inside stakes.

The field set-up is shown in diagrammatic form. The resistance will vary with the distance between the stakes so that it is necessary to calculate the resistance of some unit volume of the ground. A relationship between resistance and resistivity can easily be expressed, when the four stakes are in line and at equal distances apart, as:

$$r = 2 A R$$

in which R is the resistance in ohms; A, the distance between one stake and the next; and r, the average resistivity in foot ohms.

The depth investigated equals the distance between the stakes, so that it can be varied by merely changing the distances between the stakes. A sudden increase in resistivity indicates bed rock has been reached.



Electrical Resistivity Method

Pliable Artificial Leather

(India Rubber World, November, 1932)

IN THE manufacture of artificial leather, sheetings, textile fabrics, felts, and papers are sometimes impregnated with aqueous dispersions of rubber such as latex in natural or vulcanized condition or artificial dispersions of crude or reclaimed rubbers. The rubber is then coagulated by drying or treatment with dilute acid, followed by vulcanizing the impregnated product if desired.

It has been found that if artificial leather sheetings are mechanically worked and stretched while wet and then dried, they are made remarkably pliable and at the same time improved in strength, stretch and tear resistance. An apparatus designed for this purpose, shown in the illustration, operates as follows:

The rubber impregnated roll of sheeting *a* is first passed into a soaking bath of water *b* in which guide rollers are arranged in a lower series *c* and an upper series *d* to keep the sheeting submerged in its passage through the tank. The water soaked sheeting emerging from the bath is passed with gentle squeezing effect through a series of pairs of soft rubber covered rollers *e, f,* and *g*. The rollers of each pair may be driven at the same peripheral speed in order to avoid rubbing action and bruising of the faces of the sheet, but the rollers *f* should be driven a little faster than the rollers *e*, and *g*, a little faster than the rollers *f*, to effect longitudinal stretching of the sheeting.

Between rollers *e, f,* and *g* are mounted rollers *h* and *i* having herringbone ribbed surfaces so that the tensioned sheeting passes over them in tight contact with the ribs. Rollers *h* and *i* need not be positively driven; their rotation is effected by the frictional engagement with the wet sheeting.

From the stretching rollers the wet sheet passes around a drying drum *j* and is wound dry on a roller *k*.

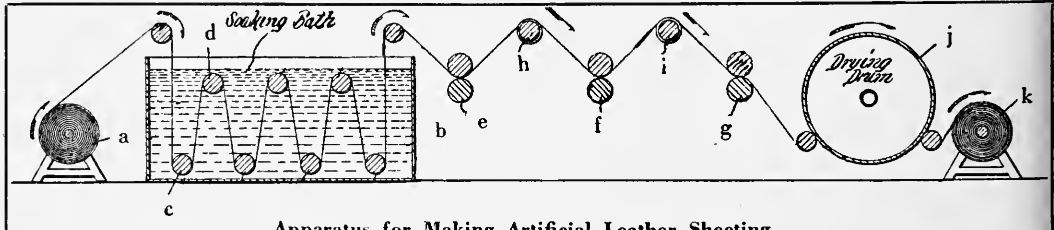
The mechanical working while wet, after once having been dried, results in a physical change in the form of the impregnated rubber making the material tough, leathery, and elastic.

Combining Hydro with Steam Improves Power System Economy

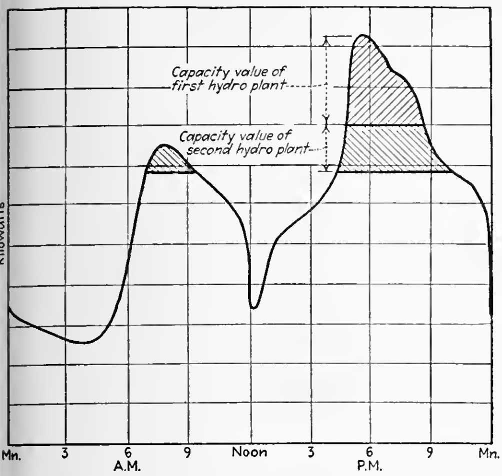
By Carroll F. Merriam

(From *Power*, Sept., 1932)

APPLICATION of the fact that hydro is a fuel saver, allows 24 hours continuous power at time of minimum flow, and has firm capacity far in excess of that corresponding to minimum flow, has resulted in the combination of steam and hydro plants to produce a new economy of operation. Hydro involves a high first cost, but a low operating expense whereas steam demands a comparatively low first cost and high operating expense. It is due to a proportioned load that their combined economy is better than that of either alone.



Apparatus for Making Artificial Leather Sheeting



Combined hydro and steam plants permit generation of 10,000 kw. for 24 hours, then 120,000 kw. for 2 hours, or 240,000 kw. for one hour. Excess capacity by hydro supply in a large system will reduce the over-all cost of energy.

The first hydro can replace steam capacity to an extent many times that of the steam itself. With additional hydro the hours of operation for the additional units must be longer; as capacity is added, the revenue from the sale of kw.h. per kw. of capacity becomes less.

To sum up, it is evident that in spite of apparent proof that it is no longer feasible to develop water resources, hydro power is being developed in accordance with economic principles which are controlled by characteristics of problems peculiar to the energy supply and type of plants common on rivers in the eastern part of the country. Steam and hydro are not rivals, but partners. Hydro plants, particularly low-head run-of-river developments, can perform distinct services when operating in parallel with steam stations. These include: generation of energy, replacement of steam-plant investment, greater flexibility in scheduling boilers and standby capacity, rapid mobilization of reserves, and maintenance of frequency.

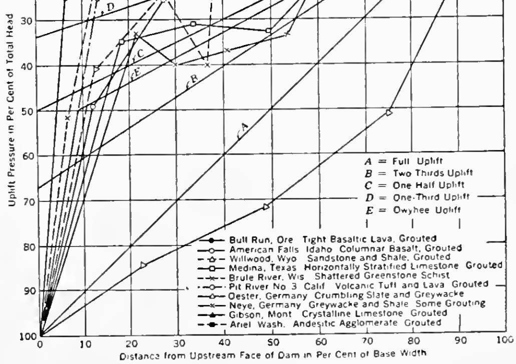
Uplift Pressure in Masonry Dams; Measurements at Existing Structures

By Ivan E. Houk

(From *Civil Engineering,* Sept. 1932.)

Up to the present times, measurements of uplift pressure have been made on only ten masonry dams built on brick foundations. In order to make proper allowances for the effects of uplift pressure in designing masonry dams, the engineer needs to know two things; first, the intensity of this pressure at different locations between the upstream and downstream faces of the dam; and second, the proportion of the horizontal cross-sectional area on which this pressure acts.

For comparative purposes, the curves of intensity of uplift pressure usually assumed in designing concrete dams are included in the Figure. Curve A is a straight line drawn from full reservoir pressure at the upstream face of the dam to zero pressure at the downstream face. Curve B shows the uplift pressures which, if applied to the full horizontal area, will give the same effect as the Curve A pressures applied to one-half



and one-third the areas, respectively. Curve E shows the assumption for the Owyhee Dam, the uplift pressure in this case being reduced to one-half the reservoir pressure at the location of the drains, and the pressures represented by the curve being applied to the full horizontal areas.

Thus far no measurements of uplift pressure at horizontal construction joints have been published. No appreciable uplift pressures have been observed at construction joints in the Gibson Dam, even under heads as high as 112 feet, and at distances from the upstream face of the dam as small as 6 feet. It is understood that no appreciable pressures have been noted at construction joints in the Ariel Dam under heads up to 115 feet; and that only comparatively small pressures have been found at the Bull Run Dam, under heads as high as 166 feet, and at distances from the upstream face as small as 5 feet. Consequently, for purposes of design, it seems safe to conclude that assumptions of uplift pressure applicable to the foundation level of a masonry dam will be more than ample for horizontal construction joints at different elevations above the base.

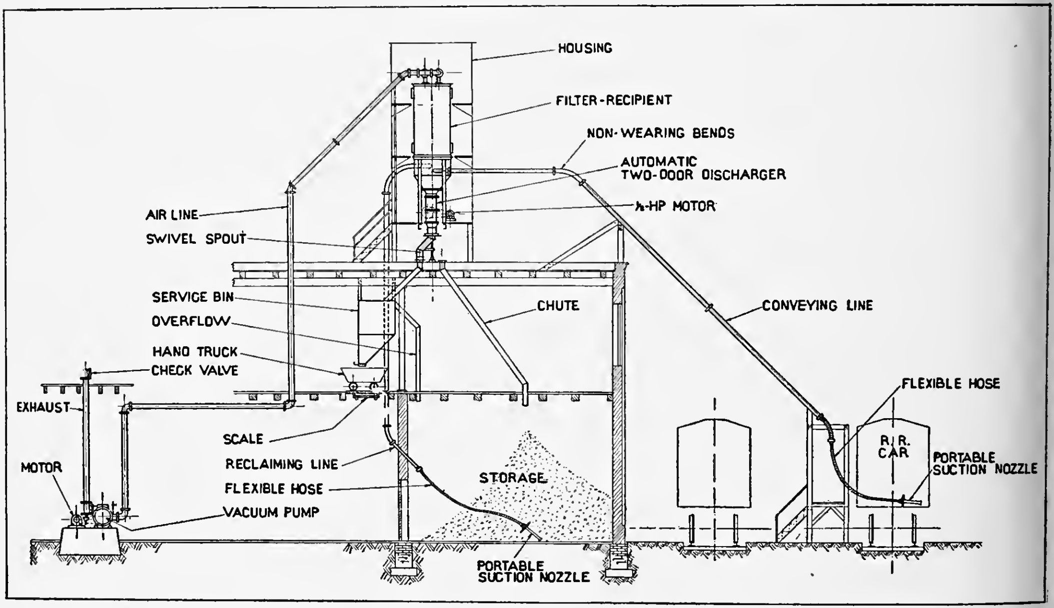
Eliminating the Dust Nuisance by Air Handling Methods

By John Weits

(From Ceramic Age, Oct., 1932)

DUST is constantly being created in the handling, grinding or mixing operations of almost all industrial, chemical and allied plants. Particularly when unloading and rehandling loose bulk materials by shovel and wheelbarrow it is impossible to prevent some of the fine material from rising into the air.

One of the most effective means of eliminating dust in the transfer of bulk materials is found in the pneumatic conveyor. Pneumatic conveyors operate either with compressed air or vacuum, or a combination of both. The vacuum type is commonly



A Schematic Drawing of the Pneumatic Flint and Feldspar Handling Units at the Plant of the General Electric Company, Schenectady, New York

employed where materials must be conveyed from several scattered points to a central point.

A system of this kind consists of but three major parts:

(1) A vacuum pump or exhauster for producing the required air currents.

(2) A recipient or expansion tank where the materials can be separated from the air and discharged.

(3) A conveying pipe, with flexible hose and intake nozzle.

Depending on the nature of the material, variety of sizes, and local factors, pneumatic systems may be stationary or portable. There does not seem to be any limitation as to capacity or distance with this method. There are systems in operation, for example, which handle fine ores weighing 140 lbs. per cu. ft. over 1200 ft. horizontally and 100 ft. vertically.

An interesting system was recently installed in the General Electric Co. plant at Schenectady, N. Y. for moving flint and feldspar from box cars into either service tanks or storage. Referring to the drawing, a fixed pipe line is mounted on a platform at the siding. To the end of this is connected one or several lengths of flexible hose, with a vacuum suction nozzle at the intake end. The pipe line runs from the siding to the overhead recipient tank, erected over the bins. The function of this recipient tank is to release the material from the air. The fine dust is filtered out of the air before it passes to the vacuum pump. The material is discharged into the service or storage bins by gravity through an air lock without breaking the vacuum. An interesting feature is the overflow connection between the service tank and storage bins, making it unnecessary for the operator to stop unloading when the service tank is filled. The same arrangement can be used to transfer the material from the storage bin back to the service tank.

Probable Applications of Gaseous-Tube Lighting

By Ward Harrison

(From Electrical World, Nov. 19, 1932)

WE MAY well preface such a discussion with the almost axiomatic proposition that, excepting a few specialized cases, light sources are employed for one of two principal purposes: (1) to illuminate other objects, or (2) to be seen as a signal or advertisement.

The 5,000 to 15,000-volt low current neon and mercury tubes with which we are so familiar in electric signs are included in the second group mentioned above. Many people overlook the fact that as illuminants these low wattage tubes are less efficient than ordinary incandescent lamps, and markedly less than mercury tubes. Practically all the development work being done on gaseous tubes as general illuminants is being done on lamps designed to operate at 220 volts or lower.

The sodium vapor tube seems now to be the most promising light source from the efficiency standpoint. Efficiencies of from 50 to 70 lumens per watt are indicated in sizes of 300 to 500 watts. These lamps have been made in sizes as small as the 25 watt size, but it does not appear that the efficiency can offset the cost of production in sizes smaller than 100 watts. This high cost is due, first, to the necessity of using glass which is resistive to the active sodium vapor and, second, to the fact that the completed sodium lamp must be enclosed and the space between the two bulbs evacuated. Without this heat insulation sodium vapor will condense and the lamp will not operate satisfactorily.

Mercury and Neon Tubes—Like all arc lamps the efficiency of these tube sources becomes very much lower as the wattage is reduced. In 300 to 500 watts the efficiency of 16 to 18 lumens per watt attainable with the mercury or neon tube is no better than

the older Cooper-Hewitt lamp or for the corresponding sizes of incandescent lamps. In ratings of 100 to 150 watts the mercury and neon tubes are not one-half as efficient as the incandescent lamps.

The typical electric lamp used in this country has an average size of a little more than 60 watts. As converters of electricity into light these lamps are little more than 10% efficient. It is very conceivable, therefore, that they will at some time be replaced by more efficient converters, but at the present time there is not the slightest reliable evidence that such a lamp has been discovered.

Thermostatic Metal—or Bimetal Nature and Utility

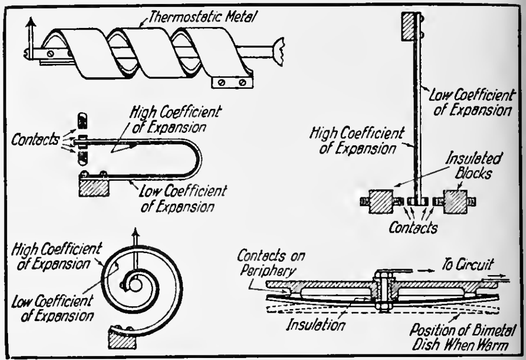
By H. Scott

(From Metal Progress, November, 1932)

THERMOSTATIC metal, or bimetal for short, forms the actuating element in many devices that unostentatiously control temperature or protect electrical machines for us.

Bimetal is a composite sheet metal, half the thickness being made of a high expansivity metal and the other half of a low expansivity metal. ("Expansivity" is really the temperature coefficient of expansion.) The component metals are brazed or welded together when in the form of two plates much thicker than the finished sheet. The joint must be good to resist the high shearing stresses which exist when the metal is warmed or cooled. The composite block is rolled into a strip, pieces are then cut out without eliminating the hardness acquired from cold rolling.

The mechanics of action reveal that its deflection, acting as a cantilever beam, when heated over a specified temperature



range, varies in direct proportion to the square of the length and in inverse proportion to the thickness. Hence for maximum sensitivity it should be as long and thin as possible. The efficiency of a bimetal for service in exerting pressure at the free end is measured by the load at the free end required to annul unit thermal deflection. This activity, in annulling a certain amount of thermal deflection, is proportional to both the difference in expansivity of its components and to the effective elastic modulus of the combination.

Invar, the relatively cheap and efficient ferro-alloy in common use contains about 36 per cent nickel, and has an expansivity of practically zero at room temperature. Brass-invar is widely used, but is not satisfactory where temperatures much above 100 degrees C. are encountered. There are various bimetals with high sensitivity up to 100 or 150 degrees C., as well as those which have high sensitivity around 300 degrees C. Austenitic steels have been found to be of greater value than monel metal for common usage.

Although at high temperatures high stresses exist in bimetals, it has been found that a bimetal used as a thermostatic element at 300 degrees C. operated 325,000 times requiring a period of 4½ years of alternate heating and cooling as rapidly as possible.

ENGINEERING PROGRESS

NEW DEVELOPMENTS AND DISCOVERIES IN SCIENCE AND INDUSTRY

Testing the Soundness of Rivet Holes

AN INSTRUMENT has been recently devised which is designed to reveal any incipient cracks in rivet holes that may lead to the failure of the riveted joint. It has been developed primarily for testing the rivet holes in boilers, but it can be adapted for testing any riveted steelwork.

It has been common practice to punch out the rivets in a joint when there is doubt as to the soundness of the rivets, but it is much more difficult to test for the soundness of the plate about the rivet. If the surfaces of the plate are studied for indications of weakness, it is found that the results of the study are almost valueless and that this method of investigation of the surface of the plate is entirely too troublesome, especially if the plate is thick. The new device, which is used to study the surface of the plate, overcomes all of these difficulties, and can be used to make a very accurate study of the material.

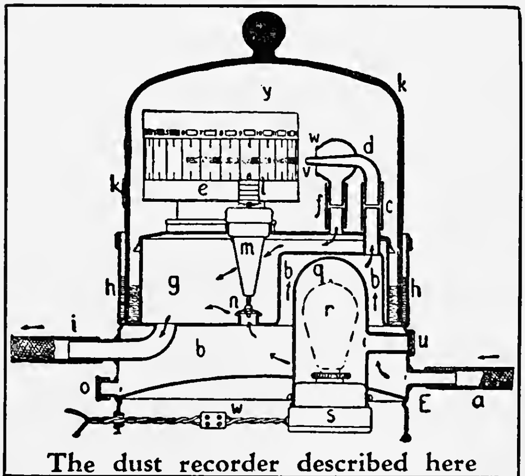
The instrument is in the form of an inverted periscope and is housed in a tube that is small enough to enter a seven-eighths inch diameter rivethole. It permits a rapid examination of the entire plate surface which has been in contact with the rivet since the field of vision is small and thus permits a closer examination of the surface. As the metal under observation is brightly illuminated by an electric lamp and magnified seven times, even the tiniest flaws and cracks can be readily detected.

If a very thorough examination is desired, the surface of the plate can be prepared by first filing it smooth, polishing it with emery cloth, etching it with nitric acid, and then washing it with water or a solution of soda to remove the acid. If any doubt still remains as to the condition of the surface of the plate, further polishing and etching will give definite results.

Dust Content of Air Recorded

IN MODERN industry the problem of the removal and collection of dust from air and gases is of outstanding importance. Sometimes it is a valuable dust which must be reclaimed to avoid waste; and sometimes it is a harmful dust which if left uncontrolled may cause considerable damage through an explosion or it may lead to the choking of a valve. A new instrument has been recently developed with the aim of making a permanent record of the dust content of a gas or air.

The gas to be tested enters at "a" in the diagram, flowing in the direction of the arrows, and passes through a heating chamber, "b," where it is warmed by a 20 watt



The dust recorder described here

incandescent lamp, "r," to help it rise. The gas then flows up through "d" and issues from the nozzle "v" on to the chart, which is rotated by clockwork. Because the particles of dust in the gas have considerable velocity, they penetrate into the paper chart and become sufficiently firmly embedded to prevent their falling off or blowing away; thus a band of varying shades is formed upon the chart. The gas having thus given up a part of its dust is deflected back through "f" into the exit chamber "g" from which it leaves the instrument. In order to obtain the utmost clearness of indication the chart paper is supplied in either of two colors—white for dark dusts, and black for light dusts.

Water Standards for Industry

THE water supplied to a community must meet certain requirements which are rather rigid and uniform. The water supplied to industry must meet additional and very different standards, differing not only from the standards of the community supply, but differing also in the various industries. Probably of most interest to water works men are the requirements of water used for making ice, soft drinks, boiler feed, and laundry and textile industries.

Ice at present is generally made from raw water rather than from distilled water as was done formerly. The ideal water for making ice is one that is free from any dissolved or suspended matter. The most troublesome impurities in water used for making raw-water ice, are the bicarbonates of calcium and magnesium. Iron is another objectionable impurity, and none of these are removed in the treatment of water for the community supply. When water containing the carbonates is frozen, an opaque white deposit is formed, which is objectionable. The best method of removing these impurities is lime treatment, which removes the calcium and magnesium carbonates bodily, and the iron precipitates as an insoluble hydroxide. Obviously, these special methods of treatment cannot be expected from the community water treatment plant.

The principal requirement of water for the laundry and textile industries is that it should be free of iron and of "zero hardness," that is, containing no calcium or magnesium, and for this property we must turn to zeolite softening. But even if a community could afford to use the zeolite process for its water, this step would be impractical and illogical because a few grains of hardness are necessary in water pumped through mains to provide the protective coating to the metal surface. Here again, therefore, we have a set of requirements that the community water supply can meet only part way.

The water used for carbonated beverages must be clear and free from objectionable taste, otherwise it will interfere with the appearance and flavor of the beverage. High alkalinity is objectionable in that it neutralizes the flavoring acids of the beverage. The diversity of special considerations involved in water treatment for the soft drink industry makes it impossible for the city treatment plant to attempt to cope with all these problems. This is properly the problem of the bottler himself, who can now obtain help from reputable manufacturers of water treating equipment with specialized experience in the bottling field.

Good water for boiler feed purposes, and particularly for the modern high-pressure boiler, must be extremely soft, for the prevention of scale, and must yield a minimum of soluble and suspended solids upon evaporation from the boiler. In order to meet these rigorous requirements, the raw water must be softened either by the lime-soda process or by the zeolite method. Other

industries require additional standards of water, and thus the difference between rational water treatment for the community supply is distinguished from water treatment for industry.

Electronic Chimes in Bell-less Church-tower

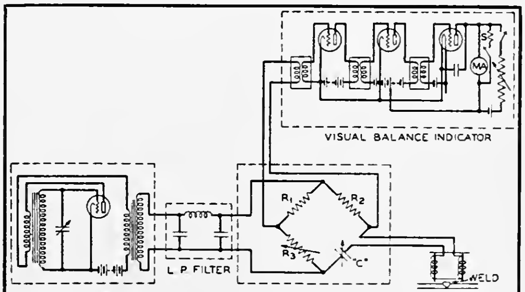
THE installation of what is believed to be the most elaborate and complete system of electric chimes in the world has been completed in a church-tower near Detroit, Michigan. The new carillon is comparable in volume to the most elaborate and weighty bell chimes, although it does not utilize bells. The bell-like tones of the new carillon are all produced electrically, the lowest note on the keyboard being equal to the tone of a forty ton bell, according to engineers who designed and installed the new system. The instrument also includes a special reproducing apparatus through which organ music may be played.

The new electric carillon represents a distinct advance in the control which the carillonneur has over his instrument, in that its entire musical range is controlled from a forty-nine note, piano-like keyboard. By pressing the keys lightly, light strokes are produced on the carillon; pressing the keys all the way down results in a volume of sound which may be heard at a great distance. As the keys are depressed, tiny hammers strike tuned metal reeds. The musical vibrations produced are electrically amplified into bell-like tones and sent out through a special sound projection system located at the top of the tower. The direction of the music may be regulated by cutting out any of the six individual sound projectors. The electric carillon system is expected to prove especially valuable in places where bells are impracticable because of the excessive bulk and weight which must be hung in existing belfries and church towers.

A Bridge Method of Testing Welds

SINCE the advent of welding, there has been an ever-growing demand for a simple and satisfactory non-destructive test for welds. Many systems have been devised and successfully used, but were limited to the shop and laboratory. A satisfactory non-destructive tester should possess the following characteristics: the device should be portable; it must give instrumental indication of flaws; and it must also indicate the relative strength of the weld as compared with the stock from which it was made.

As the work of investigation in this field progressed, it was believed that an A. C. bridge with a visual balance indicator offered the greatest possibilities. The basis on which the bridge method operates depends upon the fact that when an air-gap is introduced into a magnetic circuit, the inductance and effective resistance have new values. A series resonance bridge connected to the exploring device as shown in the figure, measures the change in inductance and the effective resistance of the exploring device, as the latter is slid along the plate directly over the weld. If the weld is as good as the stock from which it was made, the bridge balance will remain



Sketch of Tester

undisturbed, but a blowhole or burned place will change the inductance and resistance, and thus unbalance the bridge. The efficiency of the weld is computed as the reading of the tester over the stock, divided by the reading over the weld.

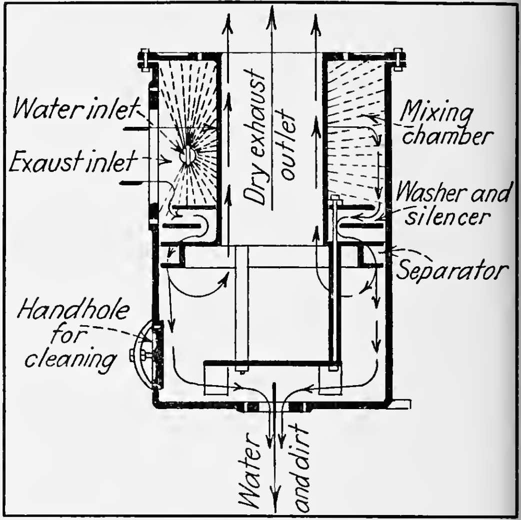
After several welds were tested by this device, they were then put through a tensile test to obtain an actual breaking load for each one. Even when the bridge apparatus was of simplest construction, the efficiency obtained from its data followed the efficiencies found in the actual destructive tests. After the bridge testing technique and apparatus was improved the results increased in reliability. This shows rather conclusively that the basic theory is sound and that the errors which occurred were due to imperfect apparatus and not to theory.

As the apparatus was being improved, the characteristics of a perfect device as stated before were strictly adhered to, and as a result, the device follows each necessary condition. Its size is portable because only a small amount of current is needed and thus the weight is materially reduced. The second and third requirements are also fulfilled as the indications are visual and the readings show a direct comparison with the stock. The apparatus is being constantly modified for use in testing all kinds and shapes of welds, and with each improvement, the reliability of the method is being increased.

Exhaust Washing Silencer

BY COMBINING a water scrubber and a Maxim silencer, a compact and very efficient silencer for gasoline and gas engines has been developed. It is claimed that it will eliminate the possibility of exhaust line explosions. This feature will make the silencer very valuable on oil tankers where Diesel engines are used as it will eliminate sparks from exhaust.

The device is built of cast iron throughout, thus making it virtually corrosion-proof. Only a moderate amount of cooling water is required, the normal cooling cir-



Details of Silencer

culation being sufficient to operate the silencer effectively. Its other important advantage over corresponding standard silencers is that it is very much smaller and lighter.

Pavement Roughness Recorded

A DEVICE which has proven very valuable in helping to produce smoother riding surfaces, was developed recently by the Los Angeles County Road Department for the purpose of measuring the smoothness of roads. This machine, similar to a recording straight edge, consists essentially of a light metal frame with a metal wheel mounted at each end, the distance between the bearings being ten feet. When the device is wheeled along the pavement, a wheel guided by roller bearings and mounted on a vertical slide, exactly in the center of the frame, rises and falls freely to maintain contact with the road surface.

The motion of the center wheel with re-

gard to the frame is transmitted to a fountain pen which records it on profile paper, and the relationship between the movement of the pen and that of the wheel can be fixed at any desired ratio. As used in Los Angeles, the pen moves two units to each unit of vertical movement of the central wheel. The profile paper moves across a light metal table, being kept in motion by a set of gears which are actuated by a rubber tired driving wheel in contact with the road surface, at such a speed that the graph produced has a horizontal scale of 1 inch equals 10 feet.

Tentatively, a method of rating has been adopted in which the deviations are counted and given weights. The sum of the weighed deviations is then divided by the product of the number of graphs made of each section of the roadway and the length of the section in miles. Graphs made of a number of roads constructed before the use of the machine, called the surface meter, indicated that those roads have high roughness ratings. Since the use of the surface meter, however, the roughness ratings show that steady improvement in the quality of workmanship is being made on stretches of road.

Until recently, the rating for the first day that the meter was operated was rather high. Then, day by day, it became lower. Now, however, paving crews and resident engineers are becoming more skillful as a result of this continual check and comparison, so that the first day's rating for each job is usually comparatively low. In addition to the information secured by comparing the roughness ratings of various sections of pavements, a study of high and low places on the graphs often reveal some peculiar condition that can be explained by the method of construction. Often this information has made it possible to eliminate the cause of deviation and to effect considerable improvement through changes in technique and equipment.

Motorless Carbon Dioxide Meter

A NEW type CO_2 meter featured by the absence of a motor in its operation, has been placed upon the market recently. The device functions on the following principle, which maintains constancy in the flow of gas under test. Inlet gas is drawn from the boiler by a separate unit and forced into the analyzing part of the recorder to pass down through a bottle which is filled with dry lump calcium chloride. This absorbs the moisture out of the gas which then flows through a pipe into a chamber and escapes.

The CO_2 content is absorbed by passing the gas over a porous plate and then in turn running it into a chamber containing liquid caustic potash. This creates a partial vacuum above the liquid KOH level in the chamber, which causes an inverted sealed bell float to change its level in a tank, moving a pen arm.

The bell float is suspended on two needle point bearings. The float in turn is balanced with a weight while all adjustments for making the pen arm read higher or lower are made with a pendulum.

CONTRIBUTORS' PAGE

BRIEF BIOGRAPHICAL SKETCHES OF OUR AUTHORS

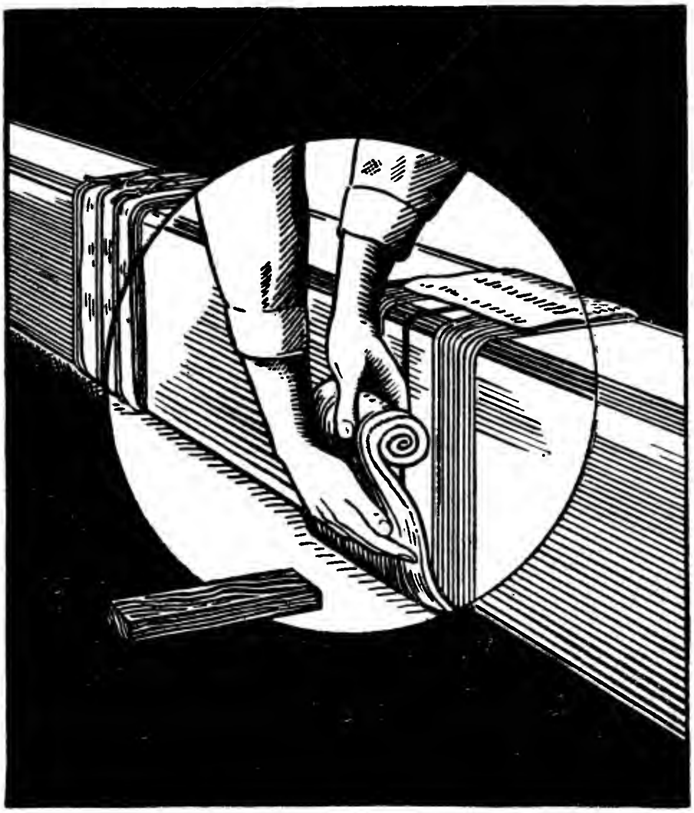
DR. M. A. GROSSMANN is the author of "Development of Stainless Steels and the Present State of the Art." Born in Youngstown, Ohio, and having received his S.B. from M. I. T. in 1911, Dr. Grossmann received the degree of Sc.D. from Harvard in 1930. He is an outstanding metallurgist and has been employed in that capacity by a number of the larger steel firms; he is at present connected with the Illinois Steel Co. He is a member of A. S. S. T., and was a Campbell Lecturer in 1930. Mr. G. G. Thorp, president of the Illinois Steel Co., and a member of the Board of Trustees of Armour Institute of Technology, was largely responsible for the good fortune of the ENGINEER in obtaining this article.

PAUL J. THOMPSON, a junior electrical engineering student, is the author of "Lightning, A Review of Progress Made in Its Study." This is the prize-winning paper of the Eta Kappa Nu sophomore essay contest of 1931-32. It covers an interesting subject in a manner worthy of real consideration.

ALEXANDER H. ZIMMERMAN is the author of "The Elimination and Control of Health Hazards in Industry," which thesis was written toward his obtaining the Professional Degree of Chemical Engineer in 1931, he having obtained his B.S. in Ch.E. at Armour in 1926. He is at present a ventilation engineer for the Division of Heating, Ventilating, and Industrial Sanitation, Chicago Board of Health.

WILLIAM F. KROL is the writer of "Architecture as a Profession," and is a junior architectural student. He is a graduate of Tilden High School, Chicago, and has been employed in the designing department of Harris Bros. Co. of this city. Interviews with a number of prominent architects of Chicago aided him in preparation of this paper.

WILLIS G. BUEHNE has written "The Packard Diesel Aircraft Engine," appearing in this issue. A graduate of Lake View High School, Chicago, he is a senior mechanical engineering student. Buehne has the distinction of being the present senior class president, and is a member of Tau Beta Pi and Pi Tau Sigma honorary fraternities.



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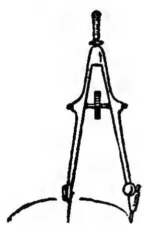

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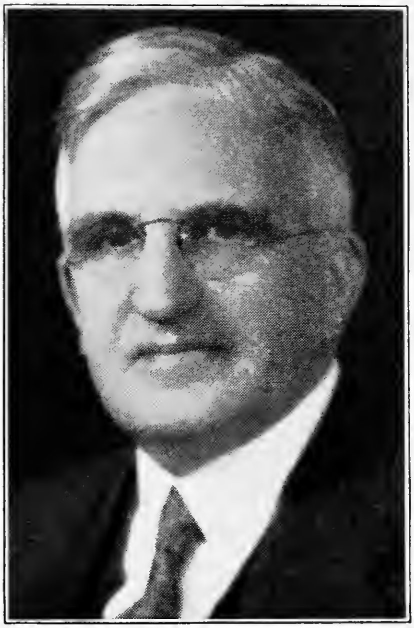

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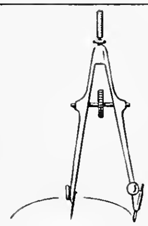

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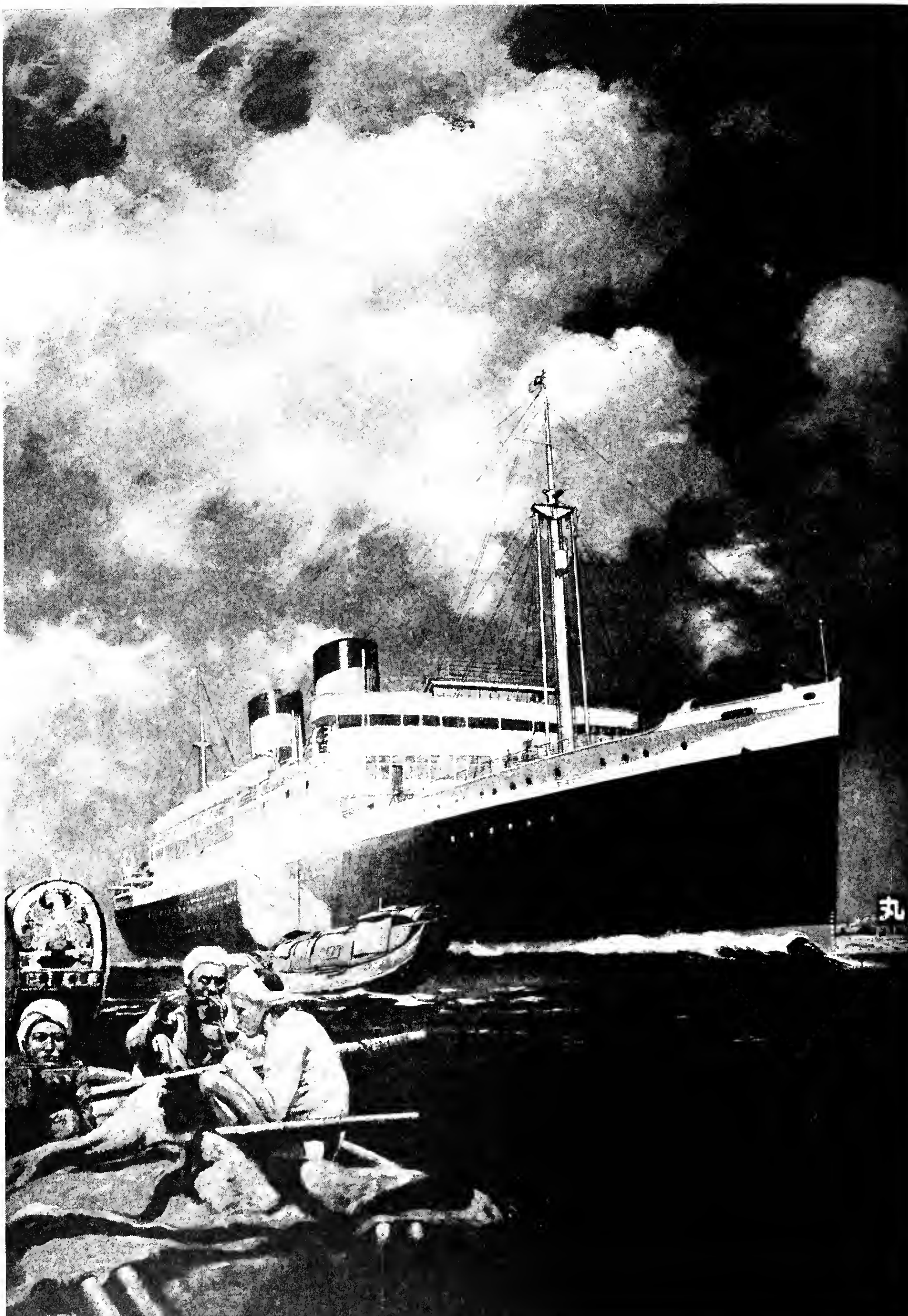

"—and Never the Twain Shall Meet"

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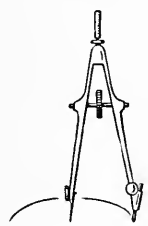
MARCH, 1933



The Ogden Avenue Improvement

By BENJAMIN F. MORRISON

OGDEN AVENUE is one of several streets which were opened or improved by the City of Chicago in the period between 1916 and the present time. These streets all form integral parts of what is known as the "Chicago Plan." This is a plan for beautifying the City and eliminating traffic congestion, slums, etc. It is the result of the work of the Chicago Plan Commission, and in its original form, called for a diagonal street connecting the southwest portions of the city with the north side. Ogden avenue was the street selected to be developed because of its location and the fact that at the southwest city limits, it connects with one of the major county highways. The street originally extended from the southwest city limits to Union Park, where it stopped, and traffic northbound was forced to detour through the downtown district by way of Washington Boulevard. For the extension from Union Park to Lincoln Park, it was necessary to condemn a right-of-way through occupied territory and

to build bridges over the North Branch of the Chicago River and the North Branch Canal.

In 1916, the Plan Commission recommended to the Board of Local Improvements that the street be opened and extended from Union Park to Lincoln Park and that it have a width of 108 feet for the full distance. The Board acted upon the recommendation preparing plans and ordinances which were submitted to the City Council and in February 1919, were finally passed. Work was started during the second administration of Mayor Thompson and was carried on during the succeeding administration of Mayor Dever. Two sections of the improvement, which required only the opening of the street and the paving, sidewalks, sewers, etc., are complete. One section extends from Clark and Center streets southwest to Halsted street. The other section extends northeast from Union Park to a point between Chicago avenue and the North Branch of the Chicago River.

The work includes two bascule bridges of the Chicago Type, a reinforced concrete viaduct across Goose Island between the two bridges, a steel and concrete viaduct over the Halsted Street Plaza, and two filled approaches, one leading to the bridge over the North Branch at the southwest end of the job and one leading to the steel and concrete viaduct at the northeast end. This work will provide the last link in an arterial street extending from Lincoln Park to the southwest city limits, and in addition will provide an uninterrupted thoroughfare, free from street intersections for a distance of 2/3 of a mile, will eliminate two street car crossings, thirteen railroad crossings, segregate the traffic on Ogden avenue from that on Halsted street and through-route traffic through one of the busiest industrial sections of the city.

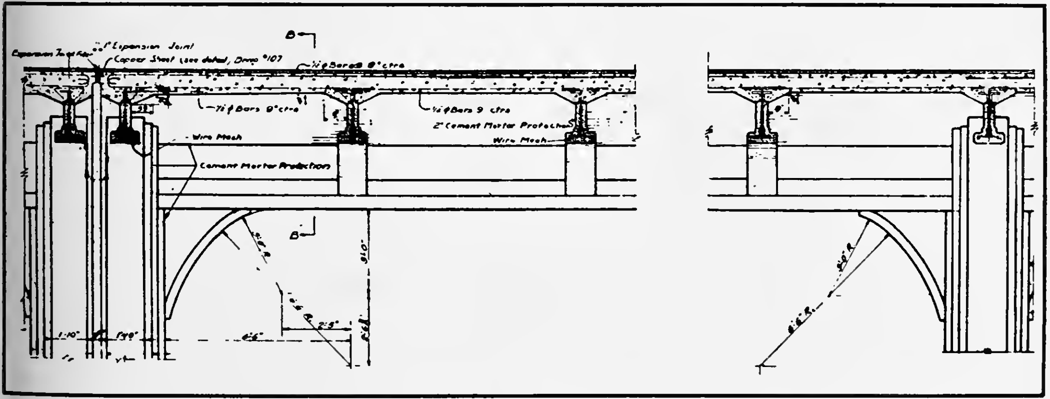
Certain conditions governed the laying out of the Improvement, and the grades and elevations on the viaducts and bridges are the results of studies and conferences held with various interested parties in an attempt to secure an Improvement that would satisfy the greatest number of people. Elevations of the roadway were in general determined by the United States War Department Requirements as to bridge clearances as well as those of the Interstate Commerce Commission, the requirements of the Surface Lines and the elevation of the Chicago and Northwestern Railway subway, crossing Ogden avenue at Cornell street. The War Department and the Division of Waterways of the Illinois State Department of Purchases and Construction were also insistent upon improving the channel and required the city to purchase a wedge-shaped strip of land south of the Halsted street bridge before they would issue permits for the bridges. This piece of land will be dredged out later thereby straight-

ening the channel. Altogether the problem resolves itself into that of fitting the structure to certain physical conditions imposed by outside agencies.

On the viaduct between the River and Canal Bridges, across the Canal Bridge and on the steel and concrete viaduct east of the Canal Bridge to a short level stretch above Division Street, the roadway rises at varying grades to an elevation of 49 feet above city datum. From the level stretch, which is above the intersection of North Halsted and Division streets, the roadway on the viaduct and approach descends to the west line of Rees street where it meets the existing grade. Although the grades in many cases approach the allowable maximum consistent with good practice, they are the best that could be obtained under the conditions and in all cases are of such a nature that high speed traffic can travel over the structures without being jolted or discommoded. The problem of designing the roadways was considerably simplified by the use of contour lines.

The Improvement does not follow a straight line from one end to the other but immediately north of the Canal Bridge the viaduct curves north and extends parallel to Halsted street until it reaches Vedder street, then curves to the east and extends in a northeasterly direction to the limits of the Improvement at Rees street. These curves can safely be negotiated by a vehicle travelling at the rate of forty-five miles per hour. No connections between the viaducts and the intersecting streets are provided for vehicular traffic, with the exception of the provision for a future ramp construction to the proposed new level of North Halsted street. Stairways for pedestrians are provided at Hooker street and at Halsted street just north of the Canal Bridge.

The ramp connection to Halsted street, referred to above, is a part of the scheme for the future development of Halsted street. This develop-



Typical deck and encasement detail

ment will include the replacement of the present North Halsted street bridge with a new bridge giving the clearances required by the War Department, raising Halsted street on each side of the bridge to meet the grades on the new bridge, raising Division street to meet the new Halsted street grade and depressing the Chicago, Milwaukee, St. Paul & Pacific tracks at Kingsbury street so they will pass underneath the new intersection of Halsted and Division streets, thus eliminating a three-way street car and railroad crossing.

The Goose Island Viaduct is a reinforced concrete elevated structure extending from the Canal Bridge to the River Bridge, a distance of approximately 938 feet. The longitudinal beams were designed as continuous members, rigidly connected to columns, for unbalanced loading and temperature. The size of columns was governed by the architectural treatment of the structure rather than the structural design. In pouring the viaduct an effort was made to avoid any appearance of sag in the beams and this was accomplished by building the beam bottoms on a camber with the high point in the center of the span.

After pouring, the columns of the concrete viaduct were vibrated by vibrating machines which compacted the concrete and gave a very dense, homogeneous concrete with a surface free from honeycomb. The beams and slabs were poured with a layer of mortar in the bottom and this gave a very fine surface. The specifications for this work provided for the various mixes of concrete for different parts of the structures and also specified the requirements and sizes of aggregates. The concrete had to be strong enough to carry the loads for which the structures were designed, of maximum density and impermeability to withstand the extreme weather conditions of this part of the country, and of the greatest plasticity because of the heavy reinforcement of the slabs and columns. In addition, the suspension of the viaduct required a concrete with a low shrinkage factor, as shrinkage, expansion, and contraction cracks are not only unsightly but are dangerous and detrimental to the longevity of the structure. It was necessary, therefore, to develop a concrete taking into consideration all of these requirements.

Having decided upon which mix to use, the pouring of the concrete was watched very closely to make sure that it did not vary. Inspectors were posted on the mixers and at the forms and samples of the concrete were taken at regular intervals. These samples were cured in sand, then taken to the laboratory and tested. A complete record of all tests was kept and the compressive strength of the concrete at the age of 28 days averaged from 3,800 pounds to 4,000 pounds per square inch.

The improvement from the north anchor bent of the canal bridge to the

abutment at the north line of Gardner street consists of a steel viaduct built of structural steel shapes encased in concrete and cement mortar protection. The roadway slab is of reinforced concrete supported by cantilever brackets. The use of a steel viaduct in this location was decided upon because steel columns would occupy less space and provide a minimum of interference with the anticipated future traffic under and parallel to the viaduct. Their location was governed by three different conditions of traffic under the viaduct. First, conditions as they now exist with street cars on Halsted street, street cars on Division street and the C. M. St. P. & P. R. R. crossing the Halsted street, Division street intersection at the existing grade; second it was anticipated that when a new Halsted street bridge is built that it will be located some distance farther east of the site of the existing bridge and that it would then be necessary for traffic in Halsted street to pass under the viaduct at an entirely different angle than under existing conditions. The columns are placed in a manner that will provide two twenty-five foot traffic lanes under the viaduct at this new angle. Third the plans of the Chicago Plan Commission provide that in the future the Division and Halsted street grades shall be separated from the C. M. St. P. & P. R. R. grade and a ramp shall be built which shall connect the Ogden avenue level to the new level of the street intersection. The viaduct columns were located so as to permit these

View of structural steel viaduct

changes without changing the viaduct.

Under the terms of the Local Transportation Franchise, it was necessary to provide for the tracks of the Chicago Surface lines, hence a trough similar to the one in the center of the viaduct was made in the roadway. The trough was filled with lean concrete that can easily be removed when the tracks are to be laid in place. On the portion of the viaduct where the future ramp will be built, provision was made so that the street car tracks can be laid in the center or on each side of the contemplated ramps.

The two bridges that form a part of this improvement are double leaf trunnion bascule bridges of the "Chicago Type." The westerly span over the North Branch of the River is 150 feet between masonry and 182 feet between trunnions. The required clearance under the bridge, and the approach grades made the available depth for the floor beams such that a three truss leaf gave the most economical design. On this bridge, we have two roadways, separated by a strip which is occupied by the center truss, and two sidewalks, making the total width of the bridge ninety feet. The roadway floor consists of creosoted planks with a covering of precast asphaltic slabs. The sidewalks are covered with the same material. The handrailing has two rails, a post at each floor beam and ornamental panels in between. It is of aluminum alloy throughout.

The easterly span over the canal is 158 feet between masonry and 191 feet between trunnions. As it was necessary to bring this bridge up high enough to clear properly Halsted street, the question of clearance over the canal was eliminated. There is no center truss, thus making a single roadway possible. The deck construction and the handrailing are the same as for the river bridge, but due to the cramped conditions at the north end of this bridge, where the pier projects into Halsted street, it became essential to keep the rear arm of the leaf down to a minimum. As a consequence, the density of the concrete counterweights, as compared to those of the river bridge, had to be increased. Steel punchings were used in both bridges to control this density.

Each movable truss of the river bridge is supported on a trunnion pin keyed into the truss and supported on trunnion columns. The operating pinions are driven by two 75 h.p., 525 r.p.m., series wound electric motors which are capable of opening the bridge in about forty-five seconds. Each motor is fitted with solenoid operated brakes and each of the gear trains have hand operated band brakes which are indirectly connected to the operating floor to be used as an emergency brake by which it is possible to stop or hold the bridge leaf in any position desired. With a few minor changes the canal bridge mechanism is the same as that of the river bridge. Each of the trusses of both bridges is fitted with sliding bolt locks

controlled by individual electric motors.

Power for the electrical operation of the bridges, gates, pumps, lighting and signals is supplied by two sources of 550 bolt direct current at each of the four bridge enclosures of the two bridges. An elaborate control system is installed, which is interlocked in such a manner that the operator must perform a specified sequence of operations to operate the bridge. These are the setting of stop signals and alarm bells, the closing of all roadway and sidewalk gates, the unlocking of the bridge, the closing of the feeder section switch supplying power to the machinery, the unlocking of the master controller and finally the opening of the bridge. Navigational signals clear automatically when the leaf has almost reached the fully opened position. With the control equipment installed, the bridge leaves are operated with a very smooth and slow acceleration by varying the resistance in the armature fields. An auxiliary controller is provided in the operator's room which can be used in case the master circuit should fail to operate for any reason. Each bridge house is heated by a steam heating plant fired by an automatic oil burner which will keep an even temperature in the house at all times without attention by the bridge operator.

True Color Rendering

By WILLIAM W. LANGE

THE correct photographic rendition of any subject depends on the true reproduction of the tones existing in that subject. A subject reflecting the most light is considered as having the highest tone value, and that reflecting the least, the lowest tone value. Then, between the highest and the lowest any number of tones may be reproduced, by the proper combination of the two. A cloud reflects a very high percentage of the light falling on it and may be classed as high in tone value, while a dark tree trunk producing the opposite sensation is classed as low in tone value.

The ordinary photographic film records the black and white tones in their true proportions because it is sensitive to the light reflected from such objects. A yellow flower appears to the eye almost as bright as a white flower, yet when the two are photographed together the yellow one comes out black. From this it is obvious that the ordinary film is not sensitive to colors. The ideal film is one whose color sensitiveness is such that, on development, the amounts of silver deposited are in proportion to the relative brightness or tones of the individual colors.

It has been known from the earliest days of photography that photographs of colored objects in monochrome produce a much different effect on the eye than the original. The general public is accustomed to such representations; however, the technical and commercial photographer must devise a means to represent truly the subject's tone values. To accomplish the natural effect it is necessary to use orthochromatic, and panchromatic materials, in combination with the proper light filters as will be discussed later.

A definition of color depends upon the definition of light. Up until about 1800 it was generally thought that light consisted of a stream of very minute particles, or corpuscles, projected from all luminous bodies with an enormous velocity. This theory fails to explain all the characteristics of light. As a result the wave theory was formulated, and it is now generally considered that light is an electromagnetic radiation just as are the radio waves, X-rays, and others. The difference lies in the wave lengths of

the radiations. The wave lengths of these radiations sensible to the eye range from .000042 cm. which is know as violet, to .000068 cm. known as red. From this discussion it can be seen that one particular wave length gives rise to a color.

A mixture of all wave lengths results in what is known as white light. If one or more of these radiations are omitted, the color we see is the resultant of those remaining. By the use of a prism white light may be decomposed and its constituents shown. The breaking up of white light into the spectrum is due to the different degrees of refraction of each wave length in glass. This phenomenon could not be explained on the old corpuscular theory.

Young and Helmholtz established the fact that there are but three nerve fibrils in the retina which respond to all the colors of the spectrum distinguishable by the eye. One fibril is excited only by the red; a second only by the green; and a third only by the blue. If each set of nerves is equally and simultaneously stimulated, the sensation of white is transmitted to the brain. By varying the intensity of one or more of these primary colors, any color may be transmitted to the brain. This characteristic of the eye makes it possible to form any color by the proper combination of the three primary colors mentioned above.

With this conception of color a red object may be considered red because it has the power of absorbing the green and blue wave lengths and transmitting the red. It is this view point that enables one to understand better the use of light filters.

All objects do not absorb the entire band of one or more colors. Most things have only partial absorption, which may be of two forms, gradual or sharp. Sharp absorption occurs on the side of the band toward the red end of the spectrum. As a result, colors bounded by a sharp edge are bright colors, reds, oranges, and yellows, while colors bounded by a gradual edge are dark colors. The sharper the absorption band the purer is the resulting color.

The sensitiveness of the eye to each color is not the same, but is greatest for green, then yellow, red, orange, blue-green, blue, and finally violet. This is known as Purkinje's Phenomenon, and is due to the association of color sensitive cones with color insensitive rods in the structure of the retina.

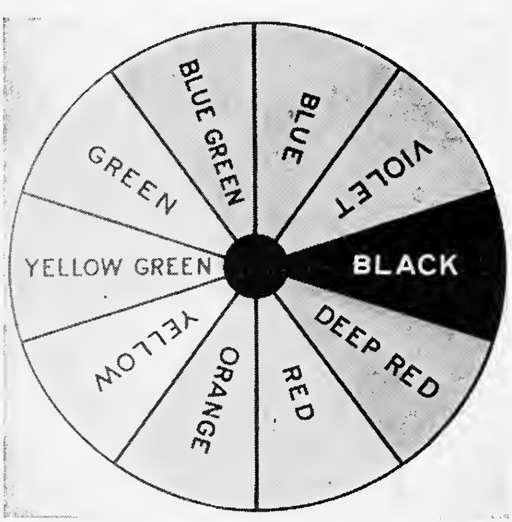
When speaking of color sensitive plates and films, we mean their sensitiveness to color other than the natural sensitiveness of silver bromide to light. The so called ordinary plate has the color sensitiveness of silver bromide while the "orthochromatic" and "panchromatic" plates have varying degrees of color sensitivity conferred on them by special treatment in manufacture. By adding certain analin dyes to the emulsion it is made sensitive to color. The degree and color, of course, depend on the par-

ticular dye used. By adding a trace of "cyanin" blue the emulsion is sensitized for red. Similarly a yellow dye "auracin" sensitizes the emulsion to green. Thus, by the use of dyes, an emulsion can be made sensitive to all colors. This color sensitivity was of little value at first, due to the inherent sensitiveness of silver bromide to an invisible radiation, the ultra violet, and its over sensitiveness to violet and blue.

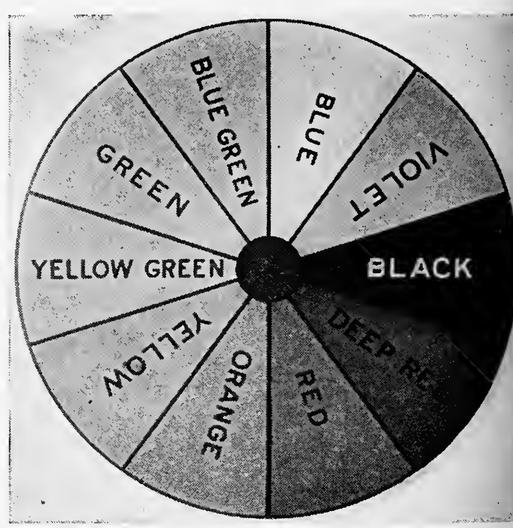
To approach true tone reproduction in a photographic record, the action of the invisible light must be eliminated, and the over-emphasized blue light record diminished and supplemented with one made by green and red light. There are two ways of accomplishing this, first by controlling the light source, and secondly by using the proper light filter.

Mid-day summer sunlight is considered somewhat as a standard white light as far as composition goes. The electric tungsten bulb at night gives a light which is comparatively white, however, turning it on in the daytime immediately shows that it has a yellow tinge.

In comparing a number of light sources we will assume that the blue constituent in each is one unit. Then in daylight the green and red will also be one. In the open arc the green content is one and one half and the red two. The yellow arc flame has a considerably larger amount of red, being twenty times the blue, whereas the green is only ten times the blue. In scanning the list of artificial light sources we find that they all excell daylight in red and green content. Consequently these artificial light



Panchromatic film



Ordinary film

Color charts with varied conditions—Artificial light

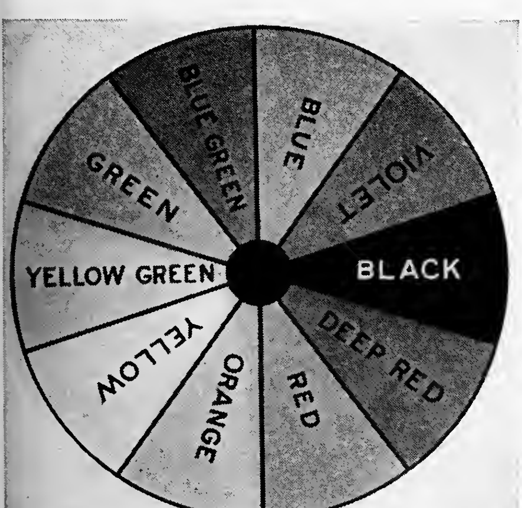
sources have more effect on panchromatic and orthochromatic materials and will necessitate shorter exposures.

In making the above comparisons the emulsions were all equally sensitive to daylight or the results reduced to its equivalent. If one works with a number of emulsions, it will be necessary to have information regarding the sensitiveness of the emulsion to daylight and the individual colors, and also the exact color content of the light source. With this information and a little experience, relative exposure times may be determined for the plate in question. Light filters may be entirely unnecessary by choosing the proper plate and light source.

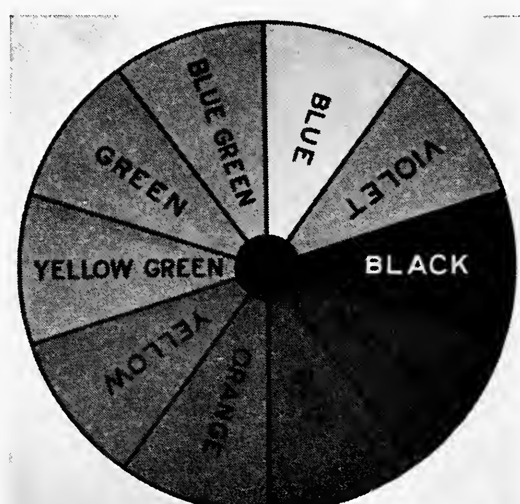
In daylight and most artificial lights the advantage gained by sensitizing a plate to the different colors would be lost unless the relative sensitiveness to the different colors was taken into account. This makes it necessary, as mentioned before, to modify the light reaching the plate when it contains too much blue, violet, or ultra violet. By passing the light through a filter, before it reaches the plate, any color desired may be removed, depending on the design of the filter.

In general a filter consists of a piece of dyed gelatine mounted between two pieces of optical flat glass, the edges of which are sealed to prevent any moisture from getting in and warping the gelatine. Filters are mounted either in front, in back, or in between the lens of a camera.

An orthochromatic filter is designed to remove all the violet and ultra violet light, and as much of the blue light as is needed in proportion to the extra sensitivity of the materials to



Panchromatic film



Ordinary film

Color charts with varied conditions—Daylight

those rays. As the most active parts of the light are prevented from reaching the emulsion, exposure must be increased, the amount being determined by the light removed and the remaining green and red rays, as well as the sensitiveness of the particular plate used. The ratio of this increased exposure to the original exposure without the filter is known as the filter factor.

Subtracting blue from white leaves red and green the resultant of which is yellow. Thus an orthochromatic filter is yellow. Early filters had many faults in that they did not absorb the invisible ultra violet, required too much increase in exposure, and were not optically perfect. Today with the increased knowledge of the chemistry of dyes, improved methods of obtaining optically perfect glass, and better emulsions, even second class filters give results far from undesirable.

To obtain full color correction, disregarding length of exposure, it is necessary to use a panchromatic plate or film with a deep yellow filter. In some cases it is desired to obtain results which necessitate over correction. In aerial photography where the greatest detail and clearness are required all haze must be removed. For this purpose an extra strong yellow filter is used. To photograph clouds merely for cloud forms, and not for pictorial rendering, a red filter is used. Filters such as these are contrast filters and differ from orthochromatic filters in that they bring about a sharp transition between the region of absorption and that of transmission.

A host of other filters is made for special purposes as in photographing grains of woods, blue prints, colored paintings, and everything imaginable where it is desirable to bring about some particular effect. One of the most striking examples is in the photographing of distant objects which may be invisible due both to their great distance and the haze between them and the observer. Here a special red filter is used which cuts out all the other colors excepting red and the extreme red, which is invisible. By using an extreme red sensitive plate and increasing the exposure a photograph is obtained equal to any taken under normal conditions.

From this short discussion it is evident that photography has been developing and that there are unlimited possibilities in obtaining special results and true, natural, exact, photographic reproductions.

Stainless Clad Steel

for Industry

By S. L. INGERSOLL

THERE are at least 125 different formulas for the production of various corrosion, heat and abrasion resisting alloys, most of which bring their metals under the classification of stainless steels. Were it not for the excellent progress made in the fields of chemical and metallurgical research, the amount of confusion which would confront the fabricator or processor in selecting the proper alloy to meet a given condition could well be appreciated. It is but natural that the manufacturers of the various alloys should wish to extend the uses of their products into as many fields as possible, and thereby often recommend the adaptation of their particular alloy to a use beyond the actual corrosion or heat resistant properties of the formula they employ. In other words, there has been a tendency for the manufacturer of a good alloy to regard his product as somewhat of a cure-all.

Progress in the field of metallurgy today has so defined the resistant properties of these 125 alloy formulas that they are well catalogued and the user or fabricator may resort to a fund of available information that will accurately define the applications and limitations as to corrosion, heat and abrasion resistance. It is well known, for instance, that an alloy of 18% chromium and 8% nickel, with low carbon content, will resist both concentrated and diluted nitric acids, but has no appreciable resistance to hydrochloric acids.

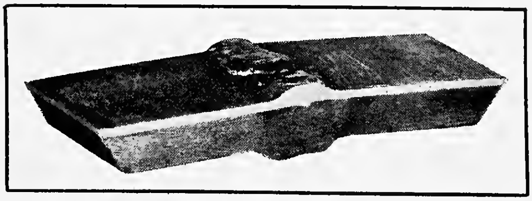
Using a wide variety of elements (many of which were unknown, or merely laboratory playthings a few years ago), we have today stainless steel alloys employing varying proportions of aluminum, chromium, cobalt, copper, manganese, molybdenum, nickel, silicon, sulphur, tungsten, tantalun, tin, and vanadium, almost inevitably combined with some carbon content. However, out of these 125 formulas, there are a few, perhaps six combinations, that have successfully met the great majority of field conditions and among these six alloys (such as 18-8 stainless, 25-12 etc.) the large

tonnage has been concentrated.

The alloys have all filled their specific niches in an admirable manner, but most of the elements introduced into steel to make it stainless have, unfortunately, been costly—so costly that countless applications that really need a stainless steel have been unable to use it. This unfortunate condition has been uppermost in the minds of the producers of stainless steels for years, and in that time they have attempted to develop substantially lower cost stainless steels.

There have been constant improvements in the methods of melting and rolling the stainless steels, and lower prices of the component elements have all tended to bring the ultimate price down, but there has been a decided limit beyond which further cost reductions could not go.

With production processes perfected, there was no way to materially cheapen the solid stainless metals and retain their desirable properties. It early occurred to many metallurgists that the apparent solution to the problem was to develop a combination metal, having a thin surface of true stainless steel and a base or back of a low cost metal. For nearly ten years, experimentation in the industry has gone forward in an attempt to produce such a combination metal. A two-ply or stainless-clad metal was the apparent solution to the problem, but until recently, no successful method was evolved which would assure (in large tonnage production) a perfect weld between the stainless surface and the base metal.



Standard butt weld

The company which has succeeded here had successfully produced many two-ply metals in their twenty years of experience in the manufacture of agricultural implements and cutlery steels. It had never been able to bring together successfully on a large production basis such remotely related members of the steel family as stainless and mild steel until very recently. On account of its long experience with ply steels, it is probably fitting that this concern should be the ones to produce a stainless-clad steel which has overcome past difficulties of production.

The method employed consists of rolling the finished sheets of the stainless-clad mild steel from a composite ingot. The stainless surfaces have been polished before the mild steel is applied, in a manner which eliminates any possibility of scale, pit marks, slivers or roll marks appearing on the stainless surface during the rolling process. The process of combining the two metals in the ingot assures a complete and perfect welding throughout the entire surface of the sheets.

The process enables the employ-

ment of any one of many formulas for the stainless steel surface. It further assures not only a complete uniformity of thickness of both the stainless and mild steel plys, but also allows the producer to vary the thickness of each ply to produce a finished two-ply sheet or plate of any commercially practical size. In other words, there is a very wide latitude in its manufacture, which will permit the production of the two-ply metal to satisfy the requirements of a wide range of commercial applications.

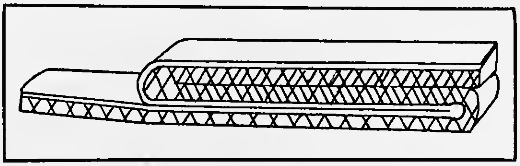
There are several aspects in the fabrication of this stainless-clad steel which merit the attention of the user and fabricator. With its usual small percentage of stainless surface, the sheets or plates may be deep drawn, stamped, formed, welded and highly polished.

It is well known that most of the solid stainless steels require approximately fifty per cent heavier equipment in fabricating than soft steel. This new material, on account of its relatively small percentage of the tough and resistant stainless surface, can be fabricated with the same equipment used on like gauges of ordinary soft steel. This becomes of importance to the fabricator who can employ present equipment and avoid the large capital expense required for heavier machinery which would be necessary in changing from a soft steel to a solid stainless product.

The stainless-clad steel is adaptable to welding by gas or electric welding methods. The method of welding has been thoroughly worked out with the leading gas and electric welding companies, and they should be consulted as to procedure. Depending upon the various gauges of the stainless-clad steel, these companies have developed thoroughly successful methods for producing lap, butt, "V" and flange welds, which assure a perfect weld embodying the stainless characteristics at the stainless surface.

For the thinner gauges, as from 16 to 10, a close fitting butt weld may be made, using a stainless steel welding rod. The weld should be made from the stainless side, and, with the proper amperage for the various thicknesses of plate, a homogeneous stainless weld for both plys is effected.

For the thicker gauges, it is recommended that the edges of plate should be "V"-ed from either the stainless or the mild steel side. To reach the bottom of the "V," a small welding rod is recommended, using larger rods as the mouth of the "V" is approached. As the weld gets well beyond the stainless ply, it may be completed, using less expensive welding rods than the stainless, at the same time assuring a perfect junction between the two different metals.



Sketch illustrating strength of bond in short radius bands

The present selling price of the stainless-clad steel is less than the cost of solid metals of like characteristics, which will bring it within the reach of countless applications where the resistance of a stainless surface has been desirable, but where the cost of the solid metals have made its use uneconomical. The fact that the process of manufacture so lends itself to large tonnage production indicates that the major uses will be in the mining, process, food and metal working branches of industry, rather than the more limited fields such as instruments, cutlery, small hardware, tools, tableware, etc., where the solid stainless metals have found such excellent application.

The character of the new material limits its use to those applications where a continuous surface is exposed to corrosion, heat or abrasion. Thus it will not ordinarily be used where the application involves piercing the metal as in screens, gravel and ore graders, etc. However, for tanks, vats, kettles, and digesters, the stainless-clad sheets will find wide application where the acid problem falls within the resistant properties of the stainless surface.

The ability of stainless steels to resist mine waters will undoubtedly result in the stainless-clad metal being used for such applications as launders, bucket and chute conveyers and pipes.

Stainless-clad steel has been used with complete success in several of the process industries in cooking vessels, vats and tanks. Likewise, the automotive industry has employed it for hardware, metal wheels, and other applications where high polish and resistance to atmospheric corrosion have been dominating factors.

In the field of kitchen utensils, the stainless surface resists discoloration of foods and the mild steel undersurface gives greatly improved heat conductivity to the skillet, saucepan or kettle.

In applications where some degree of protection or polish is desired on the mild steel side, as well as that furnished by the stainless surface, the carbon steel side may be given a low temperature enamel coating; it may be protected by aluminum, asphaltic or other resistant paints; and it may be plated by parkerizing, the Udilyte process, and others.

To attempt to enumerate the possible applications would be to extend far beyond the space limitations of this article. It is sufficient to say that it is apparent that stainless-clad steel offers large tonnage possibilities at greatly reduced costs to many branches of industry where the advantageous properties of stainless steels are desirable.

Illinois Central Lake Front Development

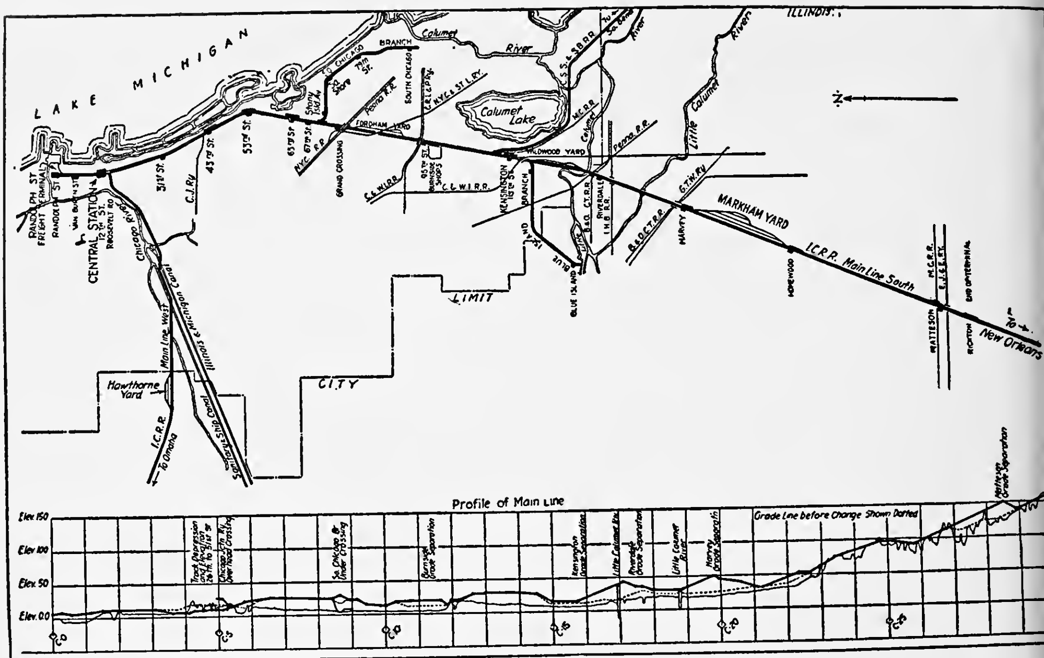
By NORMAN E. COLBURN, JR.

IN THE eighty-two years of the Illinois Central Railroad's existence it has developed to be one of the leading railroads in the country and the whole story of its progress would be of interest to any engineer. However, that task is too large for one book, much less one article, and so this article will consider only the general development of the fourteen miles between Kensington at 115th street and the northern terminus at Randolph street.

The Illinois Central was chartered in 1851. It was specified that the road should run from a point at, or near, the junction of the Ohio and Mississippi Rivers, to the southern terminus of the Illinois and Michigan canal, with a branch "to Chicago on Lake Michigan." This branch to Chicago is now the main line. Ground was broken at Chicago and Cairo on December 28, 1851.

Chicago at this time was a city of only about 30,000 people. It wanted the railroad but could not decide where to put it. The I. C. wanted a line along the Chicago River to connect with the Galena and Chicago Union, now the Chicago and Northwestern Railway. This would put freight and passenger terminals near the business district and also allow easy interchange with other railroads.

In 1851 the shore of Lake Michigan extended to the east side of Michigan avenue, and the city had been suffering severely from the encroachments of the lake. Citizens of the north and west sides had been paying heavily for years for protection against the inroads of the lake and did not want to pay for more on the south side. A special assessment had been passed in 1849 and a bulkhead had been built but about the time the ordinance to permit the Illinois Central to enter the city came before the council a storm destroyed the bulkhead and did considerable other damage. The citizens of the north and west sides then suggested that the I. C. be given a right-of-way along the lake front and thus be compelled to protect the city. This would have put the railroad



Chicago Terminal Lines, Illinois Central R. R.

right on or very close to Michigan avenue.

Michigan avenue at that time was one of the most aristocratic residence streets in Chicago and the idea of a steam railroad so close was extremely repugnant to property owners who believed that property values would be lowered. Public feeling ran high but the proponents of the lake front entrance finally won in the council. A franchise was offered the railroad to construct a line 400 feet east of the west line of Michigan avenue, along the lake shore and in the water from Randolph to Fifty-first street. This franchise was accepted reluctantly by the railroad and a breakwater was built from the river to Twenty-second street at a cost of about half a million dollars. In the eighty years of its existence the Illinois Central has spent millions of dollars in protecting itself and the city.

After obtaining the franchise the I. C. purchased all of its right-of-way between Randolph street and the river and from Roosevelt Road to Fifty-first street. The purchase of this property had transferred the riparian rights to the railroad. The submerged land west of the railroad between Randolph and Roosevelt Road was reclaimed in 1895 and a park constructed. This park is now called Grant Park and is under the control of the South Park Commissioners. About 1892 a large area to be developed as a park along the lake shore from Fifty-sixth to Sixty-seventh street

was acquired and used as a site for the World's Columbian Exposition. Jurisdiction over this land was given the south park commissioners in 1869 and the area, now Jackson Park, has developed to be one of the finest parks in the city. The commissioners also had a small park between Fifty-first and Fifty-third called East End Park. The I. C. had riparian rights along the rest of the lake front south of the river except for the three blocks between Jackson and East End Parks.

Demand for a park along the entire water front became so great that the south park commissioners finally consulted with the railroad officials to see what could be done. The law of riparian rights states that on navigable waters the submerged land belongs to the state and if this land is built up artificially title goes to the state; if the land is built up by natural accretion the land so formed belongs to the owner of the riparian rights. Therefore, nothing could be done by the railroad or the commissioners without the approval of the others. However, an act of the legislature permits park boards to fill submerged lands, for park purposes only, if agreement is reached with the owners of the riparian rights. This act also allows the owners to use some of the land so obtained for their own use, but the extent of this land must be agreed upon by the park board and the owners.

The railroad and the south park commissioners finally agreed that the I. C. should surrender its riparian rights to the commissioners who would fill in the submerged land east of a definite boundary. This agreement also required the lowering of the tracks from Twenty-seventh street to Forty-fourth street to provide for viaducts to the new park and the construction of a new through passenger station just south of Roosevelt Road. The first passenger station had been built just north of Randolph street in 1853 and was the most expensive and best equipped station in the country. It was replaced on the original site after being destroyed in the Chicago fire. In 1892 a new station was built at Roosevelt Road and this station is to be replaced under the terms of the agreement.

The agreement was finally executed but the circuit court refused to authorize the reclamation until the Secretary of War gave his approval. This was also refused until the plans were approved by the city and provision made for the southern extension of the harbor district. The council was unwilling that anything should be done until a plan for the entire lake front development was drawn up. Plans were drawn up showing the entire development program, including a passenger terminal large enough to accommodate all roads not now entering the Northwestern or the Union stations.

However, another consideration cropped up after the refusal of the secretary of war to permit the reclama-

tion. For many years there had been agitation against the smoke nuisance and, although it was proved that the railroads contribute only about five per cent of the pollution, the electrification of all the lines within the city limits was demanded by the council. Finally an agreement was reached by the city, the railroad, and the south park commissioners. This agreement is called the Lake Front Ordinance. The Secretary of War issued a permit for the reclamation work in February, 1920, and since then the work has been progressing steadily.

The Lake Front Ordinance requires the entire line to be electrified by 1940 under certain conditions. The suburban service was to be electrified by February 20, 1927, but electrified service started several months in advance of this date. The freight yard between Randolph street and the river was to be electrified by February 20, 1930. The whole yard does not have overhead wires but gasoline electric switch engines are used over the major part. All freight and switching service within the city limits is to be electrified by February 20, 1935. This leaves only the steam locomotives on the through passenger trains and the service on the Omaha Line. These will be electrified by February 20, 1940 provided more than eighty percent of the tenants then operating into the new station are electrified. Exception to this rule is allowed in the case of through manifest trains carrying fruit and vegetables. In order to meet the demands of the Secretary of War the Lake Front Ordinance makes provision for four railroad connections for the new harbor district which are provided for between Sixteenth and Thirty-first streets. Two other connections over the tracks to give other railroads access to the harbor district are required by the ordinance. The railroad is permitted to use five slips north of Randolph for switching purposes. Another requirement is that the Randolph street viaduct shall be reconstructed and widened. The railroad has completed its part of this viaduct but the city has not started yet.

The ordinance also authorizes the construction of a connecting line, extending from the Illinois Central tracks south of Eighteenth street to a connection with the Omaha line of the Illinois Central and the Atchison, Topeka and Santa Fe tracks near Archer and Wentworth avenues.

Upon completion of the new passenger terminal south of Roosevelt road, all railroads so desiring may use the facilities of the station at terms agreed upon by them. If an agreement can not be reached the Interstate Commerce Commission shall determine the terms to be used. At present, the railroads using the passenger facilities are the Michigan Central, the Chesapeake and Ohio, and the Big Four.

The park commissioners plan to have a continuous park system running from Jackson Park to Grant Park

and a bridge over the river near its mouth to connect with Lincoln Park on the north. The park development consists of two sections, one directly west of the railroad and adjacent to it which now contains the outer drive. The outer section will extend from Roosevelt road to Fifty-first street and will lie east of a lagoon 500 to 800 feet wide and five miles long. The north end of this lagoon is the road out to the planetarium which will lie at the northeast corner of the outer section of the park. The lagoon will be so constructed as to permit boat racing and other aquatic sports. Several bathing beaches will be situated along the west side of the lagoon. Thus, Chicago will have a park along practically the entire water front.

Economic Stability, Fallacy or Future Possibility

By R. S. KENRICK

AFTER the painful experiences of the economic unpleasantness which has upset the normal functioning of business for about the past three years, many of us are willing to listen to proposals designed to cure our business ills. There are plenty of patent medicine purveyors who are shouting their wares from one end of the country to the other. And, of course, most of us would prefer greater stability of employment and greater security of home and happiness. The benefits which would accrue from a more stable economy seem very tempting to almost everyone who has given any thought to the subject.

But if we strive for greater stability we must know very definitely the fundamental causes of our instability. Diagnosis must precede any prescribing of remedies.

It is becoming increasingly evident that human nature is really at the bottom of most of our economic troubles. Shall we reform human nature? This is perhaps an unfair question, because it is possible that methods may be devised to hold natural impulses in check through social agencies, without attempting to reform the individual nature of man. Herein seems to lie our best hope of accomplishing something really constructive and workable. But is it too early yet to say that we are ready for such socially-minded schemes?

A reading of current material dealing with our depressed economy reveals substantial disagreement as to the fundamental structure of our system. Almost everything from stock speculation to technical progress in production (technocracy) has been blamed for the present depression. And the bankers (all types) have not been overlooked in the search for a good scapegoat.

Unemployment is always a distressing problem, particularly so at the present time because of the aggravated condition brought about by the downward swing of the business cycle. That type of unemployment brought about by the increasing mechanization of industry is also serious enough

to demand the closest study of our best minds. We must find the ways and means to alleviate technological unemployment, without sacrificing the material benefits to society which have resulted from our scientific achievements.

What is prosperity? Well, in brief, it is that condition of our economic organization where purchasing power is rather extensively distributed and practically all of our people who are in good health mentally and physically are gainfully employed. There are always considerable numbers who cannot secure employment because of personal deficiencies.

On the other hand, a period of business depression is characterized by a sharp curtailment in total purchasing power, coupled with a tendency toward more intensive distribution of the depressed level of purchasing power. Unemployment increases to the point where it becomes a very serious social problem.

It is important to note that a condition of depressed business can be brought about without at first reducing the total national purchasing power, but merely by reversing the trend toward diffusion of purchasing power into one of relatively greater concentration. A gigantic national lottery heavily participated in by most of our people would set up such a condition. Stock market and real estate speculation succeed beautifully in accomplishing the trick of switching the savings of small wage-earners and salaried folk into "stronger hands." Financial writers carelessly glorify this transfer of wealth by using meaningless phrases to distract the attention of those unfortunates who have to swallow the losses.

Basic Structure of Our Economic System

In our present highly-complex society, no single individual is a self-sufficient economic unit. That is only possible in a very simple agricultural form of life. The outstanding feature of our industrial complexity is the ever increasing interdependence of one individual upon another, of one community upon other communities, in order to maintain a reasonably satisfactory standard of living.

The success of our present system depends entirely upon the degree to which we succeed in maintaining a free exchange of commodities and services.

In the process of production, we create value, and in the process of consumption, we destroy this value.

The destruction, or perhaps depreciation, of value is rapid in some cases and very prolonged in others. For example, food products, which form an essential part of our daily diet, are consumed frequently within several hours of their purchase. The commodity is permanently removed from the existing supply. On the other hand, some types of capital goods depreciate in value very slowly, frequently retaining a good share of their

initial value for a period of many years.

The important thing is to realize that our economic system depends for its very existence upon both the creation of values in commodities and services and the subsequent depreciation of these values. In other words, consumption in the true economic sense, is nothing more than the process of depreciating values. One process cannot go on without the other, if we hope to achieve any substantial degree of stability in the business world.

Origin of Purchasing Power In our mad rush to achieve wealth by mass production which has characterized the development of this country since the advent of the automobile industry, we gave little heed to the problem of how purchasing power arises. During the period of rapid growth, no matter how large a volume of production was reached, there was usually plenty of purchasing power somewhere in the country to absorb the commodities.

After intensive technical development in practically all industries, the country has reached a stage where there is no longer an adequate distribution of purchasing power to absorb all the goods which the highly efficient machinery of modern industry can produce. Economists and business executives are now face to face with the fact that production and consumption must be more nicely balanced.

The process of production is the origin of all purchasing power. It can only be created by the production of goods or services; never by speculation or gambling, although these operations are tremendously important in determining the ultimate distribution of purchasing power.

The production of consumer goods must be studied separately from the production of capital goods, because each exerts a distinctive influence upon the functioning of our economic system. As most everyone is aware, there is generally more stability (measured by physical volume of output) in the consumer goods industries (as a group) than in the capital goods industries. The lesson is plain. Any man who desires maximum security of employment should endeavor to get located in a consumer goods industry, preferably one where the consumption cycle is short.

Consumption begins at the time of purchase and continues until the commodities become devoid of value. Obsolescence is accelerated by style changes and technical improvements. It is evident that obsolescence hastens depreciation faster than physical wear and tear. Because of this, it is a vital factor in stimulating the sale of goods. Witness the stress put upon new technical improvements by the high-pressure merchandisers of automobiles, radios, refrigerators, etc.

By their nature, the service industries find their "product" consumed immediately at the time of purchase. There is no possibility of prolonging the consumption cycle. Thus, the

service group of enterprises represents the hypothetical goal toward which the merchandisers of commodities are striving in their efforts to increase the turnover of goods. Needless to say, the consumption of most of the articles we buy can never be immediate and complete, no matter how much merchandising talent is exerted in this direction.

Generally speaking, capital goods depreciate more slowly than do consumer goods. For this reason it is very easy to invest more money in production facilities than can be economically justified. The over-production complained of so frequently as the cause of the depression is really not so much an actual excess of commodities in every case, as an excess of productive facilities.

Under-consumption is becoming a more popular phrase than over-production because it recognizes the maladjustment existing between actual need for goods and inadequate distribution of purchasing power to satisfy that need. This faulty distribution of purchasing power, which prevents many families in the cities from consuming the farmers' produce that must be left to rot on the ground, is one of the major factors responsible for instability of our economic machinery.

The orthodox economists try to explain this maladjustment of agricultural production and consumption on the basis of "unsatisfactory prices."

Why not try to find out precisely why such extremely low prices are brought about? It is just barely possible that urban unemployment and low agricultural prices are somehow related. And, what is more to the point, it is even possible that some hitherto unrecognized factor is really the cause of both the farmers' plight and the unemployment distress of our cities. When discovered, it will be found to be a most influential factor in causing our violent ups and downs in business. Then it will be time to readjust our machinery so as to obtain greater stability. But, as in medical science, the diagnosis must be correct before any measure can be initiated to accomplish the desired stability.

Our Money and Credit System The foregoing explanation of our exchange system has made no mention of money or credit. Every one knows, of course, that money enters into every business transaction, for it is the universal medium of exchange. The purpose in not introducing a discussion of the function of money in the previous explanation is to bring out clearly the distinction between purchasing power and money.

The purchasing power previously referred to can theoretically exist without money, although it is practically impossible to effect exchanges without such a medium as money. The purchasing power is created solely through the production of goods and services. Money can act also as a storage medium for purchasing power.

That is to say, purchasing power can be stored in the form of money, thereby permitting the purchase of goods to be deferred to a date later than the time of creating the purchasing power.

The term, money, as here used includes not only the currency that passes from hand to hand, but also what is known as bank credit. The volume of money represented by bank credit would include all bank deposits, both savings and checking accounts (exclusive of inter-bank balances). In 1929 this was roughly $59,000,000,000, or about three times the national debt. Since then the volume of money has shrunk about 25 per cent. The rate of turnover of money varies considerably; when business activity is normal, money changes hands much more freely than when business is depressed. This is clearly reflected in such statistics as weekly debits to individual deposit accounts. Currency of the hand-to-hand variety also increases in rate of circulation.

Credit Inflation and Deflation Theoretically, our banking system could exert a stabilizing effect but in practice it hardly ever does so. Why is this? During a period of increasing industrial activity, the amount of money is increased, not intentionally but unavoidably as the result of credit expansion. This increase in the quantity of money, together with the increased rate of money turnover which follows an increase of industrial activity, causes prices to rise and this whets the speculative appetite of business men and professional traders.

During the expansion of credit, the demand for goods increases, because the purchasing power of the country is temporarily boosted by the credit made available. However, when credit deflation takes place, the demand for goods falls off, because purchasing power currently produced is employed to retire bank indebtedness. The inherent instability of such a changing credit structure is obvious. Expansion of credit causes goods to move into consumption at a rate *greater* than justified by current production of real purchasing power, while the deflation of credit retards the movement of goods to a rate *lower* than justified by the current rate of production.

An increased supply of money is interpreted by many people as a genuine increase in purchasing power, which probably has a great deal to do with the "boom" psychology of prosperity. Credit inflation causes prices to rise and rising prices generally stimulate buyers into action.

Of recent years there has been an enormous increase in the use of credit to finance consumer purchases on the deferred-payment plan. There is evidence of confusion in the public mind as to the economic soundness of "buying on time."

Consumer credit merely gives certain producers an advantage over producers of other types of consumer goods, in that these more aggressive

producers obtain what is almost a first mortgage on future purchasing power and prevent its expenditure for competitive goods. When all producers can grant consumer credit there will really be no advantage accruing to any particular group of industries. From a long-term viewpoint purchasing power would be no greater than if all consumer credit were to be abolished. A widespread use of consumer credit results in greater instability of production and aggravates the upward and downward movement of the business cycle. Probably the most vicious aspect of this form of credit is the effect it produces upon wage-earners who have very little sales resistance. These people easily get in "over their head" and cannot possibly meet all of their obligations out of current income.

Can we obtain a greater measure of economic stability? To answer that question we must first find out whether Americans are willing to give up any of their traditional economic freedom for the sake of greater security for society as a whole. We know definitely that the general welfare can be promoted by stopping certain abuses of our glorified individualism, but will we pay the price? Therein lies the answer.

Mercury Arc Rectifiers for a 250 Volt Direct-Current Power Supply

By C. A. BUTCHER

ADVANCES which have been made in the quality and efficiency of mercury arc rectifiers in the past few years appear to make this type of conversion equipment at last suitable for use in at least a considerable part of the very large field of industrial applications requiring direct current at the nominal voltage of 250. The most important requirement, which is a sufficient degree of reliability for industrial service, is evidenced by installations with well over a year of practically uninterrupted service, over a wide range of load requirements.

The higher purchase price of power rectifiers has been an apparent rather than a real barrier to their use, since very often the lower installation cost and better all-day efficiency than for other types of conversion equipment, more than off-set the price differential.

Rectifiers will not immediately supplant converters and motor generators for all or even a large part of industrial applications, but the present quality of the rectifier justifies an investigation in most cases for ratings of 50 KW. and above, and for voltages of 250 and above. The promise of gains in efficiency and flexibility, and possibly in cost, for future designs gives present applications and further justification of providing the foundation for further progress.

In the following paragraphs an effort is made to describe the multi-anode, metal tank, mercury cathode rectifiers now available, in terms of adaptability to industrial loads. Of course, the need for conversion equipment arises from the recognized superiority of the alternating current system for generation and distribution, and from the necessity of providing for the large number of load requirements which are satisfactorily met today only by direct current motors.

As the connecting link between alternating current generation and distribution, and direct current utilization, we first had the motor generator and later the more efficient synchronous converter. Thirty years ago the rectifying characteristic of mercury vapor in a vacuum was discovered. Since that time scientists and engineers have labored to produce mercury arc rectifiers. The first metal tank rectifier was built 24 years ago. In America, however, only within the past five years has there been any extensive use of metal tank mercury arc rectifiers in capacities of 500 kw. and above, and with very few exceptions, the applications are limited to the higher voltages, 500 to 3,000 volts direct current for electric railways.

The internal voltage or arc potential of a given mercury arc rectifier is nearly constant, increasing only slightly with load current; thus the efficiency of the rectifier is nearly constant. This internal voltage drop is also essentially independent of the terminal voltage, so the efficiency is approximately equal to the ratio of the output voltage to the output voltage plus the arc voltage. The internal loss determines the proportion of the rectifier design, and is proportional to the load current; therefore, the kw. rating is practically proportional to output voltage. Or roughly, a rectifier rated at 750 kw. at 750 volts direct current, would be rated 250 kw. at 250 volts direct current. On the other hand, a calculated weight of copper and iron will produce a generator of a given kw. capacity which, within certain limits, is independent of output voltage. So it is obvious that at the lower compared with the higher output voltages, the mercury arc rectifier is at a disadvantage from both the points of efficiency and cost.

The conventional type of rectifier becomes a competitor of the synchronous converter at approximately 500 volts, and has an increasing advantage in both efficiency and cost, as the output voltage exceeds approximately 800 volts. The limits of the competitive range are altered somewhat with the larger single tank ratings, since in single tank rectifiers, limitations of design enforce an increase in arc potential, with a resultant decreasing of efficiency. The synchronous converter and the direct current generator, of course, do not have a similar limitation.

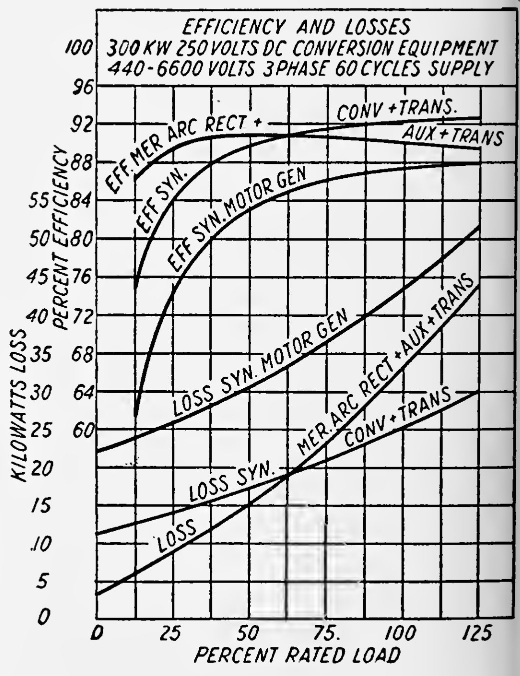
Recognition of the inherent advantages of higher efficiency coupled with adequate reliability and greater flexibility in both application and use for the smaller ratings, has led to the development of the sectional type, in which large capacities are built up of smaller capacity sections capable of use either singly or in groups, as may be dictated by conditions of load, requirements of maintenance, etc. The concentration of development work on both the design and manufacture of a small number of designs, has

made possible the progress which now opens the way to the broad field of use for the 250 volt industrial applications.

The supporting frame required for installation of more than one section as a unit provides the means of making a self-contained, factory assembled complete structure of the rectifier element with all auxiliaries for maintaining vacuum, circulation of cooling water, excitation and for control of these auxiliaries. The sectional rectifier is thus inherently inexpensive to install, and provides a compact, finish, installation.

One of the outstanding benefits secured from the sectional construction is the flexibility in use. The individual sections can be removed from service if need be, for maintenance or repairs, while the rest of the sections are continued in operation. In order to make this flexibility as completely available as possible, the frame has been so designed as to allow convenient and quick removal of a section. The section is mounted on ball bearing wheels. All electrical connections are made with standard disconnecting contacts. Water connections between the sections and the frame are made with flexible rubber hose, providing insulation where required and flexibility through the necessary limited motion. A completely independent vacuum system is provided for each section so that no vacuum connections need be disturbed when a section is removed. This arrangement also allows a section which has been out of service to be put into operating condition with its own vacuum system before installation in the frame. All sections are completely interchangeable.

Although practically any arrangement of the required number of sections is feasible, in the usual installation it is found most convenient to use assemblies of two sections one above the other in a single frame, with the various auxiliary devices mounted at the back of the frame. In this arrangement, the various electrical auxiliaries, including the power supply units for excitation and those for the vacuum relays of both sections, are mounted on the top of the frame. The protective and control devices required for the auxiliar system are mounted on a standard hinged switch-



board panel on the rear of the frame. All parts are thus easily accessible.

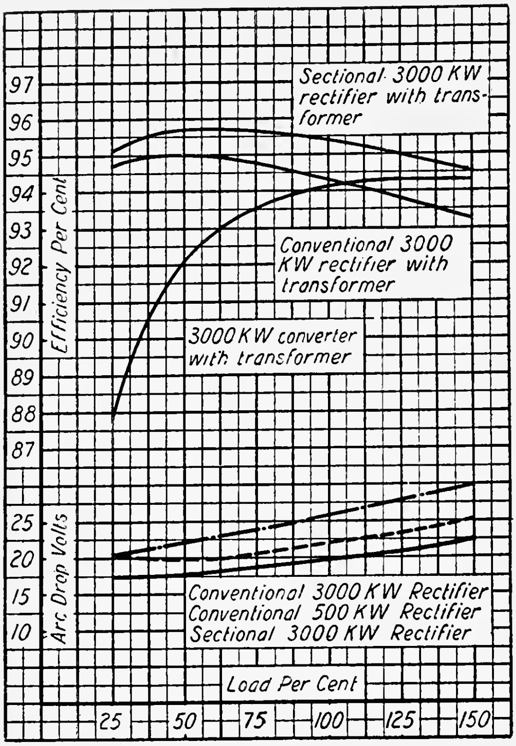
In order to get an idea of the adaptability of the available designs to this new use, we must first consider the nature and the requirements of the contemplated apparatus.

Recognizing that direct current will always be necessary for certain industries, especially for electrolytic processes, let us consider specifically the field of the metropolitan system of direct current supply. The conversion of alternating current to direct current in large centrally located substations, together with low voltage direct current distribution, even in heavily concentrated load centers, has been recognized as costly, and inefficient by comparison with alternating current distribution. That this is recognized to be true, even at the lower voltages, is evidenced by the rapid growth of the low voltage alternating current network system in many metropolitan areas. In a number of these, load is being transferred from the direct current to the alternating current network, with the idea of ultimately eliminating the older direct current network. In nearly every case, new load is to be taken only on the alternating system.

Consumer investment in direct current utilization apparatus such as motors for elevators, pumps, blowers and for driving machinery is so great in many instances as to constitute a financial barrier to the execution of a program to change over completely to the alternating system within a short period of time. But it is also obvious that in the normal course of events, the consumer's equipment will probably not become worn out or obsolete, and thus ready for replacement for some years to come. Therefore, it is to be expected that either the older direct current network must be retained at least in part, or provision made for conversion apparatus connected to the consumer's service to provide the necessary direct current. It should be feasible in most cases to transfer the consumer's lighting load directly to the alternating system. Substitution of alternating current motors for small direct current motors such as are ordinarily used on lighting circuits should not prove expensive when considering the probable saving due to the reduced conversion capacity required to supply only the consumer's power circuits.

In many areas it will probably be most economical to effect reduction of the direct current load by making all normal replacements of utilization apparatus with alternating current equipment, although some plan of cooperation between the consumer and the power company must be worked out to provide for such additions to load demand that a direct current consumer's business may require, otherwise the direct current distribution system would continue indefinitely.

To provide for such direct current



capacity as the consumer considers essential and to avoid excessive investment in a change over from one system to the other, and still take advantage of the higher efficiency of alternating current generation and distribution, conversion apparatus of one type or another will be required. The type to be used should be selected on its merits considering the following:

First Cost Including Installation.
Reliability.
Operating Efficiency.
Operating Cost.
Maintenance.

Complete equipment for a small rectifier installation for 250 volt direct current supply will cost today probably 50% more than that for either a synchronous converter or a motor generator. But the increase in cost of the equipment may be largely off-set by the lower cost of installation. There is usually a space on a consumer's premises that may with more or less alteration be utilized for a small substation. This space very likely may be so located as to offer a serious problem in the matter of adequate ventilation for rotating apparatus. Also sound-proofing may be required to prevent complaints from noise-conscious tenants. Special foundations would be, of course, required. Since none of these is necessary for an installation of rectifiers, it is probable that the resultant lower cost of installation may in many instances more than off-set the additional cost of the rectifier equipment.

Studies that have been made indicate that mercury arc rectifiers, at least in capacities of 1,000 kw. and less at 600 volts, have, on the whole, records of service continuity at least equal to other types of conversion apparatus. Over the past year, a 3,000 kw., 600 volt sectionalized type rectifier made up of four sections has in heavy duty railway service established a record of equal reliability. There is no reason to assume that in 250 volt service the reliability will be reduced.

Through a comprehensive development program coupled with fundamental research and extensive laboratory and field testing, there has

COMPARISON 300 KW., 250 VOLT D.C. CONVERSION EQUIPMENT

Including Transformer for Rectifier and Converter and Rectifier Auxiliaries.

400 to 6600 Volt, 3 Phase, 60 Cycle Power Supply

Avg. % Load 8600 Hours Per Year	Saving in Losses KW.	Annual Saving KWH at $.02 KWH		Equiv. Extra Capita Value of Rectifier Equip. Capitalization at 15%.
	Rectifier Equip. vs. Motor Generator.			
12.5	17.8	153,000	$3060	$21,000
25	17.0	146,000	2920	19,500
50	15.6	134,000	2680	17,900
75	13.3	114,000	2280	15,200
100	10.4	89,500	1790	11,900
	Rectifier Equip. vs. Syn. Conv. Equip.			
12.5	6.7	57,600	$1152	$7,680
25	5.2	44,700	894	5,950
50	2.2	18,900	378	2,520
75	−2.3	−19,800	−396	−2,640
100	−7.9	−68,000	−1360	−9,060
	Comparison of No-Load Losses			
	Motor Generator		22.1 KW.	
	Syn. Conv. Equipment		11.4 KW.	
	Rectifier Equipment		3.3 KW.	

been produced a most reliable rectifier conversion equipment, which based on a rating of 300 kw. at 250 volts has an overall operating efficiency including transformers and auxiliaries, slightly better than 90%. Compared with the 60 cycle motor generator and the 60 cycle synchronous converter for 250 volts, the relative overall efficiencies including transformer for the converter and rectifier, but not for the motor generator. If the potential of the power supply is higher than 6,600 volts, transformers would be necessary also with the motor generator, with consequent reduction in overall efficiency.

In each case, an analysis of the load cycle will be made to determine the operating efficiency. If the average load is less than 60% of rated capacity, it will be noted that compared with

typical machines, the rectifier is more efficient than the synchronous converter and that at one quarter load the rectifier has a favorable margin of approximately 5%. Even at full load, the rectifier has a favorable margin of 3% over the motor generator while at 50% load, the rectifier is better by 7% and at one quarter load by approximately 14%. Idling losses of the rectifier are only approximately one seventh of such losses for the motor generator, and less than one third of those of the synchronous converter. Since the average load is often less than 50% of machine rating, it is evident that the rectifier may be expected to have an operating efficiency perhaps as much as 10% better than a motor generator and at least equal to that of a synchronous converter in the same service. On an average load of 100 kw., and with energy at 2 cents per kw. hour, the saving by this margin of efficiency would be approximately $1,700.00 per year. This saving capitalized at 15% represents an added inherent worth of over $11,000 which certainly covers any part of the increased first cost not compensated for by other gains.

Operating costs for completely automatic equipment would be approximately the same for all three types of conversion apparatus.

The cost of maintenance should be but a small percentage of total annual charges. In general, high maintenance cost for rectifiers must result from trouble, and since there is nothing that wears out normally as do the current collecting parts of rotating machines except from corrosion of the surfaces in contact with the cooling water which is certainly controllable, a reliable rectifier should have less maintenance cost than a rotating machine.

Insurance to service continuity demands spare capacity in some measure. The usual requirements are that the maximum load shall be adequately served when the largest of a group of conversion units is out of service. Such insurance may be in the overload capacity of the serviceable units, in a complete spare unit or a combination of the two. The installation of spare equipment means added capital investment, the carrying and operating charges of which must be debited against the cost of power. Such insurance will be maximum when only one unit is required for the load and a second is carried as a spare. Perhaps, on the average, the number of equipments installed will be a total of three, all of equal rating, viz.—3—150 kw. motor generator sets, and such that only two are required to carry the load. This is logical when considering rotating machines, since with only one unit in operation during light load periods, or two units during maximum load, the units will be operating fairly efficiently. Considering the quite uniform efficiency of the rectifier, it is apparent that there is little further gain to be had in using a small unit at light load to improve

conversion efficiency. Assuming a load to be supplied entirely from one automatically controlled rectifier, viz., one rated at 300 kw., should an outage occur, the spare unit would be automatically put into operation with the lapse of only a few seconds. If even a momentary outage is a serious matter, both units might be operated continuously since even at fractional loads, the rectifier is relatively efficient. The latter is not true of rotating units and a somewhat longer period is required to bring an idle equipment into service. Considering then an installation of two rectifiers as against three motor generators or synchronous converters, the rectifier installation would have a total capacity 1/3 greater than the 3 unit layout, but would still operate with higher overall efficiency than motor generators, but perhaps to no advantage over an installation of synchronous converters. The sectional arrangement of rectifiers applied in such a case makes for economy by providing readily for subdivision, reducing spare capacity requirements.

The neutral of a 3 wire 125/250 volt system is ordinarily supplied either by a balance coil connected to the slip rings of a three-wire direct current generator, or from the neutral of the transformer connected with a synchronous converter. The most efficient means of supplying the neutral to a three-wire direct current service from a rectifier is to provide a two unit D.C.-D.C. generator, the two units being connected in series across the terminals of the rectifier, with the neutral tap being made at the series connections. Since the load is ordinarily fairly well balanced, only a small capacity set would be required. But since neutral is necessary only for lighting circuits and since conversion losses may be saved by connecting the lighting to the alternating current system, a direct current neutral would not ordinarily be essential.

It appears that the study of specific examples will disclose many cases in which the rectifier is best suited to the requirements. This gain in available conversion units will make it economically sound to proceed with some change-over projects which have not been justifiable previously.

As the developments in rectifiers progress at the present accelerated rate, further gains are to be expected in the matters of efficiency, size, cost and controllability, and thus these gains will greatly enlarge the useful field of the mercury arc rectifier. The prospects seem most promising that the industry may soon begin to receive a return from the rectifier development commensurate with its very great cost.

THE TECHNICAL BOOKSHELF

REVIEW OF NEW BOOKS OF ENGINEERING AND SCIENCE

Electronics

By Ralph G. Hudson

(John Wiley and Sons, Inc.)

IT IS quite probable that the advancement of science during the next quarter-century will relate more definitely to electronics than to any other subject. Each step in progress may be expected to suggest practical applications of electronic theory which will give man increasing control of the forces of nature." Such is the opinion of Prof. Hudson in his work on the fundamental idea of matter—the electron. The purpose of his book is to provide information for the reader who may wish to gain some conception of the base of which all matter consists and who has not hitherto given the subject much attention.

The author has accomplished this exposition with the desired results, and almost entirely without the aid of mathematics. However, it is desirable for the reader to have some knowledge of physics and elementary electricity, since the work deals entirely with electrical phenomena and embodies comparisons involving principles of mechanics.

The subject starts with a brief outline of the atomic, particle, and quantum theories, and leads up to a description of the processes involved in the determination of the mass, velocity, and charge of the proton and electron. From the constitution of matter and conduction in solids, liquids, and gases, the author gradually approaches the photo-electric cell and concludes with a detailed explanation of such modern improvements as television, telephotography, and sound print for the blind.

Drawings are submitted wherever possible and footnotes and bibliography are omitted in view of the fact that very few readers of elementary texts have occasion to refer to original sources of information. A table of electronic constants completes the work.

Determinative Bacteriology

By Lehmann-Neumann-Breed

(G. E. Stechert and Co., $12.50)

THE exhaustively complete and famous Lehmann-Neumann-Breed Determinative Bacteriology translated into the English is now obtainable to the users of the Armour Library.

For the engineer the new methods of

sewage treatment demand a knowledge of bacteriology, to say nothing of the work connected with food production, brewing, chemical reactions, paint production, and agriculture. Bacteria known to be the basis of human disease are also included in "Determinative Bacteriology."

The work consists of two volumes which are divided as follows:

Volume I—Technique, General Determinative Bacteriology, Atlas.

Volume II—General Bacteriology, Special bacteriology.

The Atlas is distinguished by the remarkably beautiful colored plates of specimen bacteria cultures. The artistic technique with which the drawings and photographs have been made are notable because they are clear in detail. They were drawn by R. O. Neumann.

An Outline of Wave Mechanics

By N. F. Mott

(Cambridge University Press, $2.80)

THE new theory of wave mechanics has had its inception as the result of the inability of the older Quantum Theory to agree with the wave nature of light. Wave mechanics provides the desired coordination and also accounts for all phenomena explainable under the Newtonian and Quantum Theories.

This book, based on a series of lectures, acquaints the advanced physicist with the New Quantum Theory. A complete understanding of this work requires an acquaintance with the Old Theory and a knowledge of Fourier's analysis and elementary wave mechanics.

Romance of the Heavens

By Gerald Beavis

(J. P. Lippincott and Co., $2.50)

AS AN undeveloped science, astronomy gave the ancients a basis for explaining the mysteries of nature. As a developed science, free from metaphysical conclusions, it is the basis of our modern conceptions of matter.

Much of its growth may be charged to the telescope, the all important instrument of today's astronomy. As a consequence, the chapters of this book devoted to this instrument are completely warranted. The evolution of the telescope is covered up to the present time. Particular emphasis is placed on the Mt. Wilson observatory.

THE ARMOUR ENGINEER

Student Technical Publication of Armour Institute of Technology

MEMBER OF NATIONAL SCHOLASTIC PRESS ASSOCIATION

VOLUME XXIV — MARCH, 1933 — NUMBER 3

The Student Staff

UNDER the newly conceived policy of organization of THE ENGINEER the staff has changed from senior to junior leadership with this issue. This issue has been produced by the new staff, only steadied in its first responsibility by the retiring senior executives. The new leaders have been carefully selected and trained; under their pilotage THE NEW ENGINEER can advance even further.

Civilization

ARE we civilized? This simple question has been the subject of debate among psychologists, econo-

mists, and physiologists for years, without any definite conclusions being drawn. Inasmuch as the engineer may be held partly to blame for any lack of civilization occurring at the present time, it is well that he give the matter some thought.

It is indeed foolish to declare that we are living in a civilized state simply because we have complicated machinery and labor saving devices to alleviate the human burden, when these same machines are the direct cause of thousands being unemployed. Can we possibly say this era is one of civilization when these thousands of unemployed, and their families, are starving, and at the same time engineers are creating machinery which causes increased cultivation of crops and other food, a great quantity of which remains unused? It is for this reason that the engineer receives his share of bitter criticism.

One of the obvious remedies, and one which will spell the success of the machine age, will be the provision of shorter working hours, enabling an increase in workers, and spare time for them to secure the maximum happiness out of existence. This time must be desired by the people, not forced upon them. It is here that the engineer must step in with machinery enabling added enjoyment of this spare time. Then we shall be closer to civilization.

THE GUEST EDITORIAL

Science a Common Language

IN THIS AGE of specialization every specialist has to cooperate with other specialists. Goethals, the engineer, built the Panama Canal, but Gorgas, the physician, kept his force alive. Basically, the two men approached their problems in much the same way because, in addition to their separate technical lingoes, both spoke the common language of science. When engineers, doctors, lawyers, musicians, and architects let their separate lingoes create a barrier to mutual understanding, everyone loses. Your standing in your profession is largely conditioned by your ability to appreciate and cooperate with men in other fields. The best instrument for doing this is a scientific habit of thought. The more you develop such a habit, the more you are able to comprehend the other man's speech and his mode of thought, and to realize that essential qualities among men of science are much the same in all professions. In cultivating the common language of science, engineers come to value men as men rather than as engineers, physicians, or lawyers.

—Dr. Willard E. Hotchkiss
President
Armour Institute of Technology.

THE COLLEGE CHRONICLE

NEWS OF THE HONORARY GROUPS AND DEPARTMENTAL SOCIETIES

Armour Relays

ON MARCH 18th Armour will again be host to one of the largest gatherings ever assembled in the middle west for an indoor track meet. The occasion is the second Armour Relays. The reception with which the largest indoor field meet ever held in Chicago was met last year insures an even greater enthusiasm this year. Nearly all the Big Ten Universities are expected to attend, and, in addition to this representation, every smaller college in the neighboring States probably will participate.

The meet will again be held at the University of Chicago field house, located at 56th street and University avenue. The large size and adequate facilities of the field house insures ample room for the large crowd which is expected to attend.

Swimming

THE Tech swimming team is approaching the end of the hardest season and schedule of opponents ever attempted; swimming has definitely graduated to the level of the major sports in its demands upon its squad members and in the class of opposition met.

The team has engaged Michigan State College, Wisconsin State Teachers College, Illinois Wesleyan University, Northwestern University, "B," Loyola University and Crane College during this season and has, in every meet, given a splendid account of its prowess. The above competitors rank as leading contestants in Middle-Western athletics and numbers a Little Nineteen Conference champion among them.

The team is led by Carlstrom, high point man, and has as consistent winners, Kolve, Ahern, Knaus, Burson, Bernstein, Giovan and La Force. A number of promising freshmen give Coach McGillivary high hopes for next season also.

Basketball

DUE to an operation last summer, Coach Krafft was unable to take up the strenuous duties as coach for this year's basketball team. Otto Kuehn, an alumnus of Armour, was then appointed coach for this season. Coach Kuehn had to build this year's team around a nucleus of three regulars from the previous season, Captain G. J. Beemsterboer, M. A. Lukas, and L. G. Rummel.

Among the aspiring candidates were several with prep-school experience. With the three veterans and the wealth of new material, Coach Kuehn began to mold a green team into a fast, powerful, smooth working, offensive squad. Much time was spent in experimenting to see which combination of players would prove the most effective, both offensively and defensively.

The Armour five started the season auspiciously by defeating the University of Chicago at Bartlett Gymnasium in a practice tilt. Throughout the season the team has shown a good brand of basketball and, in the games in which they were

defeated, rarely were they more than a few points behind their opponents. Although many powerful fives were on the schedule, Armour finished the season with about an even number of games won and lost.

Playing under the new basketball rules has increased the scoring by about twenty-five per cent. This meant a speeding up of the game and added interest to the spectators. Many loyal Armourites turned out for the home games at the Eighth Regiment Armory, and, led by the cheer leaders, showed that they were not lacking in school spirit.

Next season should prove even more successful than the last, with all the regulars returning except Beemsterboer.

Track

TO ALL appearances the Armour Tech track team is headed for a championship season. With the largest squad in history, over fifty men, there is an abundance of material with which to work.

There are three all-around men who have been carrying most of the burden. The squad is led by Captain Sademan, who stars in the dash, 440 and 880 yard events. The second of these men is George Nelson who participates in the hurdles, high jump, broad jump, and, if he is needed, in running events. The third man is the sophomore flash, John Roberts, who competes in the hurdles, shot put, broad jump, pole vault, javelin and the 440. With these three men, backed by the rest of the team, a well balanced squad is effected.

Up to the present time the team has had two victories and one defeat in dual meets. The defeat came at the beginning of the season, but was expected as Armour is not yet of "Big Ten" caliber. Since then, the team has been improving constantly, and barring accidents, should be the leading college track team of this district.

Freshman-Sophomore Informal

THE Freshman and Sophomore classes again will hold their dance jointly this year. This was done for the first time last year and proved to be a success. This year's dance promises to be even a greater event. Both committees, the freshman headed by Murray Hughes, and sophomore by John Ahern, have been hard at work since the semester recess. The dance will be held on Friday night, March 31st, in the main ballroom of the Medinah Athletic Club. The date is midway between the Junior Informal and the Junior Formal. This will enable everyone to attend at the utmost convenience. The Medinah Athletic Club will furnish the loveliest background obtainable for what promises to be the big dance of the year.

Tau Beta Pi

MEMBERS of the Armour chapter are quite busy in planning for the national convention of Tau Beta Pi to be held in Chicago in October, 1933. Illinois Beta Chapter, of the Institute, will be hosts, and a great time is predicted for all wearers of the coveted key who attend the conclave.

The local chapter will soon inaugurate an annual scholarship award to be given to the freshman with the highest average each year. A plaque, on which the man's name will be inscribed, will be hung in the lobby of the Main building. The

honor student will also be given a year's subscription to a magazine that will be recommended by the head of his department.

Pi Tau Sigma

PI TAU SIGMA recently held an election of officers for the spring term at which time the following men were elected.

President	R. J. Dufour
Vice-Pres	R. E. Nelson
Treasurer	N. C. Penfold
Recd. Sect.	J. Moravec, Jr.
Corr. Sect.	E. W. Gosswiller
Cataloguer	M. J. Erisman

Plans are now being formulated for the annual convention of Pi Tau Sigma which is to be held in this city during the early fall. As the Century of Progress Exposition will then be open, a considerable number of members of Pi Tau Sigma will probably attend this convention along with the regular delegates. The problem of entertaining and securing accommodations for these visitors is one the Armour chapter must solve.

Phi Lambda Upsilon

OMICRON Chapter of Phi Lambda Upsilon held its formal initiation Thursday, January 23, at the Phi Kappa Sigma house. The three new members who now wear the key of the society are: Vincent J. Galvani, K. Lewis Hackley, and Walter G. Hollmann, all senior students in chemical engineering.

As a part of the evening's program, the pledges were required to divert those present for an hour. Needless to say, the entertainment was of highest caliber.

The Armour Chapter sent its congratulations to the new Alpha Theta Chapter which was installed at Virginia Polytechnic Institute, February 25, 1933. The new addition brings the total number of chapters to 31.

Phi Lambda Upsilon was founded in 1899 at the University of Illinois. The chapter at Armour was installed in 1920.

Eta Kappa Nu

ETA KAPPA NU, national honorary electrical engineering fraternity, announces the pledging of the following men:

A. B. Bronwell, '33.
D. O. Schwennesen, '33.
J. D. Fernbach, '33.
W. H. Hulswit, Jr., '33.
S. G. Lehmann, '34.

A dinner dance was held during the holidays at the Oriental Gardens and a most enjoyable time was had by all those attending. The fraternity will also offer a new, Sixth Edition, Electrical Engineers' Handbook to the sophomore who wins the annual essay contest. On December 16, the fraternity initiated E. A. Dunham, E. E. Eberth, M. L. Priban, and P. J. Thompson.

Chi Epsilon

AT A meeting held on February 14, the honorary civil engineering fraternity elected officers for the current semester. The members elected to office are:

President	L. Gabriel
Vice-Pres	J. E. Schreiner
Secretary	B. H. E. Loesche
Treasurer	J. T. Mauer

E. G. Beard, Jr., has been chosen as assistant editor of *The Transit,* official news organ of the fraternity.

Salamander

SALAMANDER held a formal initiation on January 17 at the Triangle house and the following men were made members of the fraternity:

H. J. Bannasch, '33.
S. A. Vanderpoorten, '33.
C. A. Cunningham, '34.

Many alumni were present, as were all of the faculty members of the department and honorary members, including Mr. J. V. Parker and Mr. W. R. Townley. Salamander awarded a Fire Protection Handbook to the highest freshman in the department at the annual smoker given by the Fire Protection Engineering Society; this was G. W. Wheaton, '35.

Sphinx

THE honorary literary fraternity has recently completed the design of a certificate of membership to be given to each initiated member. Alumni members may obtain a similar sheepskin certificate if they wish.

The annual spring membership elections will be held soon to reward the leading juniors in publication work.

Pi Nu Epsilon

THE second Tuesday in January marked the initiation of four men into the honorary musical fraternity. These men are:

J. L. Brenner, M.E., '34
C. Clarkson, E. E., '34
M. A. Collick, E.E., '33
E. P. Reardon, E.E., '33

After the initiation ceremonies, the fraternity spent an enjoyable evening at the Apollo Theatre at a performance of "The Cat and the Fiddle."

The members expect to attend several concerts in the future.

Alpha Chi Sigma

THE new officers of the professional chemical fraternity for the present year are as follows: D. J. Mullane, president; R. W. Marty, vice-president; R. McFarland, corresponding secretary; R. H. Schorling, secretary; A. Kapecki, treasurer; K. Eberly, master of ceremonies; and J. J. Doney, alumni secretary.

An alumni smoker was held Wednesday evening, February 15th, at the Beta Psi house; and on February 1st, a pledging smoker was held at the home of Ray Stewart, X '32.

The following men have been announced as pledges:

W. G. Booth, '33
R. J. Long. '35
J. H. Miller, '33

Initiation of pledges will be held in March.

Scarab

ON THURSDAY, February 15th, the following men were initiated into Temple Edfou of Scarab, professional architectural fraternity:

L. F. Skubic, '33
C. B. Sommer, Jr., '33
W. W. Davies, '33
R. B. Tague, '34
B. R. Buchhauser, '35
L. W. Davidson, '35

The initiation was followed by a banquet at the Delta Tau Delta house. A large number of alumni were present, including instructors and business men, all prominent in architectural activities. They gave interesting accounts of their travels both in America and Europe.

The 1933 National Convention will be held in Chicago, and as this is World's Fair year, all attempts are being made to make it the best one held.

American Institute of Chemical Engineers

STUDENT members of the American Institute of Chemical Engineers have elected the following officers: A. H. Helmick, president; R. H. Schorling, vice-president; A. Kapecki, secretary; and V. J. Galvani, treasurer.

R. D. Armsbury, sophomore chemical, was presented with a membership pin to the American Institute of Chemical Engineers by the national organization for having had the highest average among the freshman chemical engineers.

Western Society of Engineers

THE Armour branch is looking forward to a talk on the designing of bridges to be given in the near future by Mr. Gustav Anton Haggander of the Chicago, Burlington, and Quincy Railroad. Mr. Haggander is in the Bridge Department of the Burlington and was graduated from the Institute in 1907. Later on the society expects a lecture from Professor Eugene and some other prominent men in engineering activity in the Chicago area.

American Society of Mechanical Engineers

THE Armour student branch of the A.S.M.E. has attempted to carry out its program of student speeches as far as possible, and the results so far have been very satisfactory. In line with this program of student speeches, we would like to remind all members of the A.S.M.E. of the silver cigarette box which was donated by the parent society as an award for the best paper submitted during the course of the year. So far, there have been very few papers submitted. This prize or award is well worth having.

Fire Protection Engineering Society

THE society is in the midst of a busy year which, so far, has seen more speakers than in previous years. Mr. R. E. Maginnis of the Illinois District Telegraph Company (A. D. T.) spoke at the meeting of January 20 and explained the essentials of his firm's many services and new developments.

Mr. Hill, an examiner, Springfield Fire and Marine Ins. Co., gave a valuable lecture on the Underwriting of Sprinklered Risks.

Mr. R. E. Vernon, Fire Protection Engineer, Western Actuarial Bureau, gave an interesting illustrated lecture at the meeting of February 24. His pictures of recent large fire losses and of the last St. Louis fire school were very interesting.

American Institute of Electrical Engineers

FRIDAY, February 24, the student members of the A. I. E. E. held a meeting for the purpose of viewing three sound films. These films were furnished by the Illinois Bell Telephone Company and were on the subjects of trans-oceanic radio and the making of sound films. A large crowd attended.

ALUMNI NOTES

NEWS OF ARMOUR ALUMNI ASSOCIATION AND OF ARMOUR GRADUATES

Alumni Association Elects Officers

AT THE annual business meeting of the alumni of the Armour Institute of Technology, held at the Medinah Club, the following men were elected to office:

President—John J. Schommer
Vice-President—F. G. Heuchling
Secretary-Treasurer—D. P. Moreton

Board of Managers:

M. W. Lee, '01
L. A. Sanford, '06

The complete membership of the Board of Managers is as follows:

Lee, M. W.
Sanford, L. A.
Stryker, C. E., '17
Regensburger, H. W., '25
Burky, C. W., '27
Pohlman, E. F., '10
Whittington, J. A., '14

Additional Vice-presidents elected were:

Friedman, R. N., Arch.
Smith, N. A., Civil
Core, N. B., F. P.
Martin, H. W., Chem.
Eustace, A. L., Elect.
Lizars, J., Mech.

An Advisory Council consisting of two alumni of each of the engineering departments and the architectural department was appointed.

At this meeting Mr. James Cunningham, President of the Board of Trustees, was elected an honorary alumnus.

Among the constitutional changes was one referring to the term of office of the president, vice-president and secretary-treasurer. Their terms were increased from one to two years.

Six additional vice-presidents were elected to function in special departments, such as financial, industrial relations, student loan fund, publicity, etc.

Provision was made for the election of three alumni trustees next autumn.

Among those at the reunion was President Emeritus Howard Raymond, who spoke a few words.

Kent H. Parker, F.P.E., '28, is with the Western Actuarial Bureau here. He occasionally substitutes as an instructor to the senior F.P.E.'s.

Milton J. Abrahamson, C.E., '28, is at Springfield, Ill., with the Ill. State Highway Commission.

D. S. Ullock, Ch.E., '26, has been studying chemical engineering at The University of Michigan during the past two years and has passed the preliminary examinations for a doctor's degree in chemical engineering.

Sidney L. Schwartz, Ch.E., '30, who is a Junior Engineer at the U. S. Forest Products Laboratory at Madison, Wis., reports that he is enjoying a course in physical chemistry under Dr. Kahlenberg.

Leon H. Fischman, C.E., '30, is now working for the government. His is located near St. Louis, and is working on the building of dikes in that vicinity.

TECHNICAL ABSTRACTS

CONDENSATIONS OF LEADING ARTICLES IN THE TECHNICAL PERIODICALS WITH PERMISSION OF AUTHORS AND PUBLISHERS

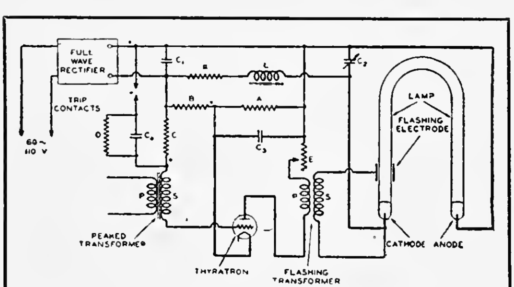
The Edgerton Brilliant-Illumination Stroboscope

General Radio Co.

(From *Instruments*, Jan., 1933)

A RECENT development of Prof. Harold E. Edgerton, Massachusetts Institute of Technology, this firstling in the 1933 crop of new instruments is of the intermittent light-source type—which type has heretofore depended chiefly on neon lamps to furnish the requisite brief flashes. Prof. Edgerton has adapted the technically desirable mercury-arc lamp to modern stroboscopic requirements.

In the Edgerton Stroboscope, the flash lasts 5 microseconds—in which time an object traveling at a mile a minute moves only 0.005″. The flash speed can be controlled accurately over the entire range ordinarily required and fundamental synchronism can be obtained up to speeds of 10,000 r.p.m. This short, brilliant flash is obtained by discharging a capacitor across a mercury-arc tube which has the form of an inverted U with internal electrodes of mercury, anode and cathode, at its lower ends.



Hook-up of Equipment

Provision is made for flashing the light in exact synchronism with the closing of a pair of electrical contacts, by the 60-cycle supply mains (60 flashes per second), or by any external source of alternating current. The maximum speed of the present equipment, determined by the regulation of the rectifier unit, is in excess of 150 flashes per second, so that fundamental synchronism may be obtained at all speeds from zero up to at least 10,000 r.p.m., while perfect synchronism of the second or third order will double or treble this limit.

All parts of the stroboscope equipment, except the lamp and the tripping contacts, are built into a metal cabinet which constitutes the power supply. This is energized directly from 110-volt, 60 cycle mains and consumes a maximum power of about 0.25 kw. Only three adjustable controls are required: the size of the lamp capacitor, a rheostat for controlling the intensity of the flashing voltage, and an adjustable speed contactor.

Depositing Oxide Film on Aluminum

By A. Eyles, M.E.

Manchester, England.

(From *Metal Industry* Jan., 1933)

THE Electrotechnical Research Institute in Moscow, Russia, is reported to have recently developed a process whereby an oxide film can be deposited on aluminum wire to withstand several hundred volts. This oxide film possesses good insulating, heat-resisting, and heat-conducting properties; it is flexible, mechanically

strong, and capable of withstanding shocks and friction. In the event of a local puncture, the heating by an electric spark will produce an intensive oxidation of the bare metal, which will then again be covered.

The extreme thinness of the oxide film, its good heat conductivity, and the large surface in contact with air create exceedingly favorable conditions for cooling, which, taken in conjunction with the very high heat resistance of the oxide film (whose melting point is 2,500 deg. C.) make possible a very considerable increase of the permissible current density. Moisture, chemical reagents and corona do not affect it; it is also very hard.

For depositing the film the aluminum is treated with oxidizing chemicals at high temperature. The chemical action of the oxidizing solution can be increased by an electrolytic process, which in its simplest form consists in anodic polarization of aluminum in a suitable electrolytic bath; the oxygen separating during the electrolysis produces the requisite action. An oxide film can be obtained in any weak acid solution and in many weak alkalis. Organic acids produce the best results; good results are obtained also with chromic, oxalic and boracic acids, and with borax and soda. To obtain a sufficiently thick formation the film on the aluminum anode must be disturbed from time to time by imposing an alternating current on the direct current.

A semi-industrial plant has been established at the Moscow Institute for the production of oxide insulated aluminum wire. The first 10,000 meters produced were employed for winding a 20-kw 6,600/550-V transformer to be used for studying the behavior of the insulation under working conditions. The puncture voltage was 300-V and the insulation was not broken when the wire was wound around a cylinder with a diameter thirty times that of the wire.

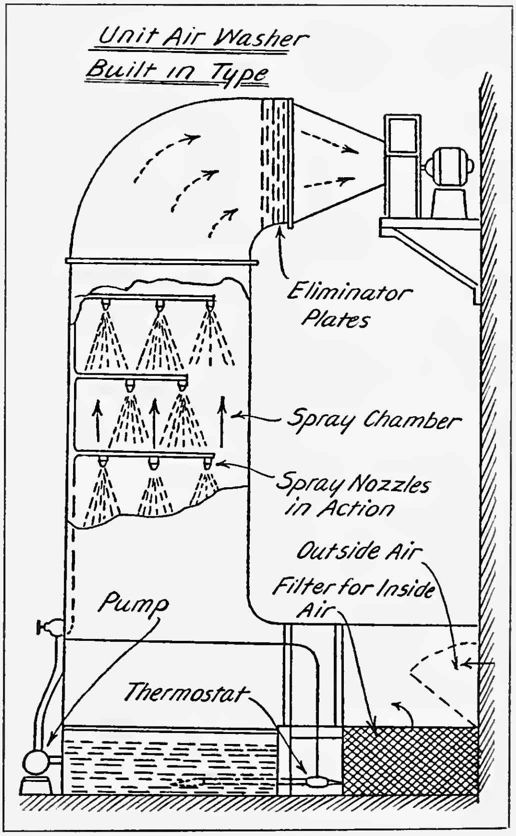
Principles of Humidification

By Malcolm Tomlinson

(From *American Artisan*, Jan. 1933)

THERE are two processes in air conditioning—humidification and dehumidification. The first puts moisture into air-water vapor mixtures. It moistens the air and raises the relative humidity. The second takes moisture out of the air mixture and lowers the relative humidity.

Moisture removal is a more expensive process than humidification. To dry air mixtures usually requires special equipment. Therefore most air-conditioning apparatus is built for humidification solely and is practically helpless to remedy inside weather at high relative humidities. It is, of course, possible to obtain air-condition-



ing equipment which will take care of either one of these processes, or both, as desired.

Some very simple methods of humidification preceded the air washer. One is the pan from which water is evaporated. Its principal disadvantage is that heat sufficient to evaporate the water needed is not always available. A second method is to blow water, in the form of a fine spray, or mist, into the surrounding air mixture. One scheme consists of a motor driven disk against which a small stream of water is forced under pressure. The speed of the disk flings the water particles from the disk edge into the air. Surplus water is carried off by a drain. Another scheme makes use of the spray nozzle in which water is forced, under pressure, into the nozzle, given a whirling motion and ejected at high velocity into the air mixture in the form of a mist. Both of these devices find considerable use for industrial humidification but neither method gives a uniform relative humidity.

The air washer not only provides a uniform relative humidity, air motion and air temperature, but also removes dust and particles of foreign matter from air mixtures. Air enters these washers by means of a fan and duct system, is cooled by a fine spray of water to the required dew point, is "scrubbed" free of dust and excess moisture by eliminator plates, is heated to the desired temperature and then delivered to the air conditioned space.

Keep Electrical Contacts Clean

By B. W. Jones

General Electric Co.

(From *Maintenance Engineering,* Jan. 1933)

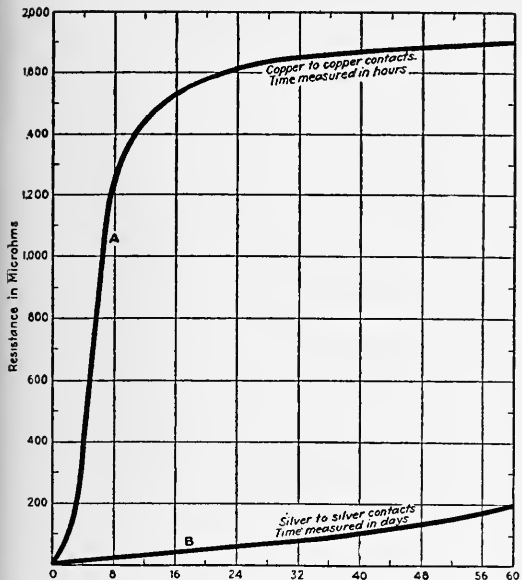
MANUFACTURERS and users of electrical devices have to deal frequently with contacts that carry currents of various magnitudes; nevertheless the characteristics of these contacts are not at all well known. Recent study of this subject has revealed some interesting and useful information.

Copper is the most commonly used material for carrying current, which means that copper-to-copper contacts are frequently used. These contacts are sometimes held together with bolts, sometimes with a spring pressure, as on fuse clips, knife switch clips, or contactor tips. Bolted contacts are put together and seldom or never separated. Of the other type of contacts, some are separated infrequently, others are separated very frequently. Some of the contacts that separate are subject to arcs, others are not. These and other variables all have a bearing on the action of contact resistance. Therefore, when analyzing any one device with regard to contact resistance, each of these factors must be considered.

Copper oxidizes rapidly and the oxide has a very high resistance, as is shown in the chart. Some copper tips were thoroughly cleaned and their contact resistance measured when they were held together with a pressure of 20 lb. The tips were then put in an electrically heated oven that was held at a temperature of 85 deg. C., and at intervals they were removed for the purpose of measuring their contact resistance. Curve A shows that the resistance increased to more than 150 times the original value.

When a contact is carrying current and as a result of the loss in it the tip becomes heated to some specified temperature as measured by an instrument, the temperature of the spot or spots across which the current flows from tip to tip is much higher than the measured temperature. For this reason, the rate of oxidation at these spots will be even faster than the curves show.

In order to obtain a conception of the importance of the active contact of a switch



Resistance of copper-to-copper and silver-to-silver contacts when held together with a pressure of 20 lb. and kept at a temperature of 85 deg. Centigrade.

or contactor it must be remembered that the contact, when thoroughly clean, may account for from 10 per cent to 30 per cent of the total resistance of the device. Therefore, when this value begins to multiply by 10 or 100 or more, it is easy to see what will happen to the switch.

If a meter test shows that a bolted joint causes too large a percentage of the total drop through the electrical device, the joint should be taken apart, cleaned thoroughly with a file (not with emery paper or the like, because the particles of abrasive will become imbedded in the copper and create a high resistance) and rebolted tightly.

When a test shows that a high resistance is in the active contact one of two things must be done: the contact must be serviced at intervals or it must be made of something other than copper. If the nature of the device is such that it is not feasible to service it, the contact face can be made of silver, a metal that gives very good results. Silver is usually adapted to the purpose by brazing a thin sheet of it to the copper contact surfaces.

Facilitating Higher Vacuums in Industrial Processes

By D. H. Jackson

(From *Chemical & Metallurgical Engineering,* Oct., 1932)

HIGH vacuum in the vicinity of 1 or 2 mm. absolute pressure was thought, not so many years ago, to be limited to laboratory apparatus. Today the same thing is being done in numerous industrial units, but many plant executives have not yet taken advantage of the improvements which this higher vacuum offers.

The steam jet type of vacuum producer (known as the ejector, evactor or thermocompressor) is the unit which has provided the high vacuum for most of the recent industrial developments in this line. The reason for this is simple. The density of any gas or vapor decreases in a definite ratio with a higher vacuum. Gases of low density will flow with much less friction loss than those of higher density, which means that they can be made to flow at much higher velocities. They must flow at high velocities in order to maintain a high vacuum in any continuous process where large quantities of steam or other vapor must be handled. The average velocity of the steam from the nozzle of the steam jet evactor is about 4000 ft. per sec., which is higher than the velocity of a bullet.

The vapor from the vacuum vessel is drawn into a Venturi throat with this high velocity steam. As the steam expands, the vapor is compressed and the two are discharged from the Venturi throat as a homogeneous mixture. The vapor passes through the ejector at velocities much higher than

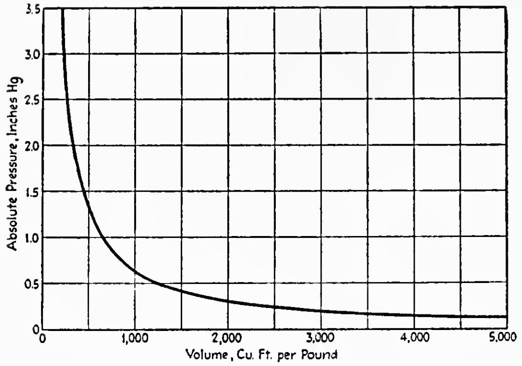


Fig. 1—Sharp increase in steam vapor with increase in vacuum

would be possible in any type of mechanical vacuum pump. In the steam jet apparatus there are no moving parts as it is rigid and the steam and vapor move through it. The low density of the entering vapor permits very efficient application of the energy of the expanding steam.

The importance of this high velocity is not fully realized until one considers the large increase in volume of a vapor at high vacuum (see Figure). For an example take the steam distillation of an organic compound. Assume the amount of steam blowing through the liquid in the still is 1000 lb. per hr. The mixture of steam and organic vapor would pass through a partial condenser where the vapor would condense. If a vacuum of 0.25 inches Hg absolute is maintained, steam will leave the condenser at 2,415,000 cu. ft. per hr. To condense this steam from a temperature of 40.2 deg. F. a cooling system of 100 tons would be necessary. If the steam were compressed in a thermocompressor to 1.4 in. Hg abs. there would be but 10 degrees difference between the condensation of the water and the steam. This would require 2400 lbs. per hr. of steam in the thermocompressor that is available at 125 lbs. pressure.

ENGINEERING PROGRESS

NEW DEVELOPMENTS AND DISCOVERIES IN SCIENCE AND INDUSTRY

Electric Forging Machine

WITHIN the last few years there has been developed a machine which will heat a steel bar as it is being upset in the forging process.

The machine is composed of a horizontal bed somewhat like a lathe bed, which supports at one end a movable anvil and at the other a hydraulically or pneumatically operated ram. Between the two is placed a pair of copper or brass guides grooved to take the bar being operated upon. The anvil is insulated from the bed of the machine and so is the saddle which supports and carries the guides. Underneath the box-bed of the machine is a heating transformer with a number of tappings for adjusting the secondary voltage, one end of the secondary is coupled to the anvil and the other to the guides.

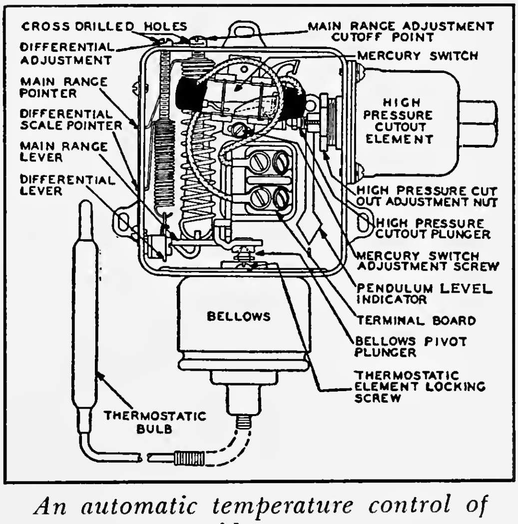
The machine operates as follows:—the bar to be upset is placed between the guides, one end against the anvil, a controi lever closes them to a sliding fit on the bar and at the same time brings the hydraulic ram to bear against the other end of the bar. Another lever then switches on the current which flows through the length of bar between the guides and the anvil with the result that as soon as this portion attains a forging heat the ram commences to force the remainder of the bar through the guides into the heating zone and at the same time causing the metal to gather itself in the form of a spherical upset against the anvil. In this way the bar is continuously fed forward through the guides until the required amount of the bar has been upset.

This machine is limited to the production of spherical and cylindrical upsets only. However when the bar is removed from the machine it is still at a forging heat and thus can be finished in a die or press. At present the machine finds extensive use in the manufacture of poppet valves for internal combustion engines.

Automatic Temperature Control

A NEW type of automatic temperature control has been just recently developed. It is available for temperatures from those of refrigeration work to a maximum of 700 degrees Fahrenheit.

When this instrument is used as a refrigerator control, it has gas-filled, remote-bulb thermostatic elements terminating in bellows which elongate or contract in accordance with changes in bulb temperature.



An automatic temperature control of wide range

The visible scales thus indicate the bulb temperature, which is the "box temperature" only when the bulb is so located as to be affected by the box temperature. The mechanism operated by the bellows consists of a wide main lever provided with hardened fulcrum grooves which pivot on widely spaced knife-edge supports. Integral with the main lever is the main operating lever which is balanced by the main adjustment spring and which tilts the mercury switch. The action of the differential adjustment spring is transmitted to the main operating lever through a uniquely designed auxiliary lever so positioned as to impose the additional tension necessary to increase the temperature differential. The mercury switch is of a new "heavy-duty ceramic type" adequate for the majority of commercial applications. Since the thermostatic element is self-contained and removable, emergency replacement is readily accomplished on the job, following which recalibration is likewise a simple matter.

Simply Operated Pyrometer Lamp

A NEW pyrometer lamp which measures within five to ten degrees centigrade of a furnace temperature has been developed. The device consists of a black-coated, pear-shaped bulb containing an inverted U-shaped carbon filament and a small eyelet about 1/8 inch apart. These are mounted midway between two windows in the bulb and in such manner that the center of the eyelet and the horizontal portion of the filament are on a line of sight between the center of the windows.

The advantage of the eyelet is that it indicates the calibrated portion of the filament and enables the operator to keep his eye focused on the plane of the filament at the time that it blends with the background.

Automatic Water Softener

A FULLY automatic zeolite water softener has recently been developed. This softener is said to eliminate the errors due to the human element and to conduct all of the operations of softening and regeneration with regularity and precision. By combining a meter-operated switch and electric controls with a motor driven single valve each operation of the water softener is conducted under precise control.

The operation of the apparatus may be described briefly:—At the end of the softening run the meter actuates the electric controls which carry through the steps of cutting the softener out of operation; backwashing it for a regulated period so as to secure thorough cleansing; admitting a carefully regulated amount of saturated salt brine so as to assure thorough regeneration without wastage of salt; rinsing out the hardness salts to waste with the minimum amount of rinse water; and throwing the softener back into service thus placing it again under the control of the meter which governs the volume of water to be softened during the softening run and also initiating the start of the next regeneration cycle.

Not only may this new device be had in the fully automatic types but it is also possible to apply the automatic control to existent downflow softeners and thus convert them from manual to fully automatic operation.

New Self-Lubricating Bearings

IN THE last few years a group of engineers have developed a remarkable bearing that will actually lubricate itself. The important advantages of this new bearing metal are as follows: The oil content is high, averaging thirty-five per cent by volume. Any desired lubricant may be

used. Certain applications require no lubricant except that originally contained in the bearing. The high oil content provides a hydraulic cushion that sustains severe pressures and shock loads, while assembling is expedited, and wear and scoring of bearings are minimized.

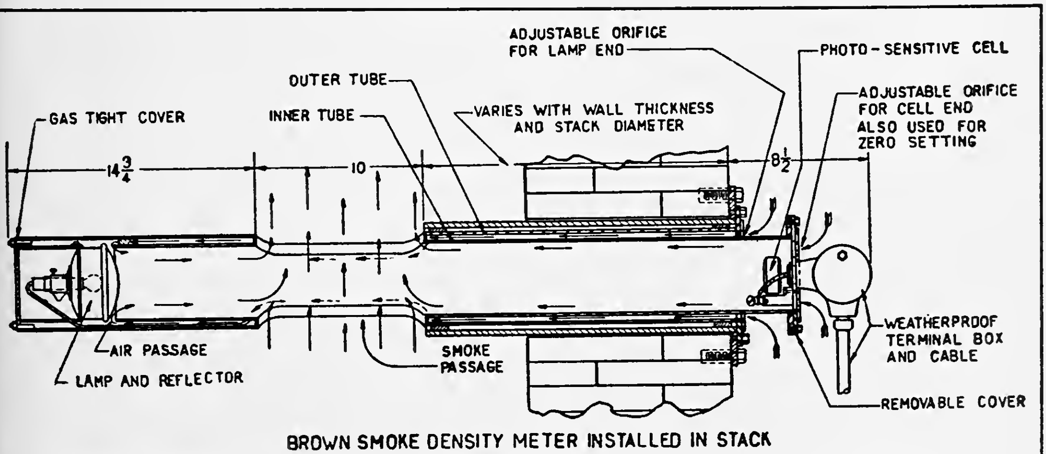
The new bearings are made from powdered virgin copper, tin, and graphite. No zinc is used in this composition. This powder is made so fine that the material will pass through a 300-mesh screen. These various powders, taken in definite proportions, are carefully weighed, thoroughly mixed and then fed into an automatic briquetting machine. Here, under high pressures, the bearings are formed into the final shapes. The final operations on the bearing are heat treatment, impregnation with oil, and final sizing of inside and outside diameters.

Oil grooves are not necessary with these new bearings as minute pores pervade the entire mass of the bearing material. If the housing does contain an oil reservoir, it is not necessary to drill an oil hole through the bearing. The bearing will keep itself fully charged with oil and yet never drip. If the oil reservoir used contains dirty oil, this new bearing material will act as a natural filter.

A spring disc made of this same bearing material was held over a flame and the heat of only part of the flame was sufficient to cause the oil to come to the surface of the bearing. Thus in actual use the heat of friction caused the oil to come to the lubricating surface. One of the test bearings was run for 75,000 revolutions without any oil except that contained in the bearing. Inspection of this bearing showed no measurable wear in either the shaft or the bearing.

Smoke Density Meter

A SMOKE density meter has been developed that is claimed to be easy to install and operate, and which requires a minimum amount of attention. It is a device for measuring the density of smoke in flue gases by electro-optical means. In this type of smoke meter a portion of the flue gas is made to pass between a source of light and a light-sensitive device. When the smoke in the flue gas varies in density, the amount of light falling upon the light-sensitive device also varies, and the resulting current variation from the photo-cell



BROWN SMOKE DENSITY METER INSTALLED IN STACK

is transmitted to the indicating or recording meter. Since there is a definite relation between the current output of the photocell and the amount of light falling upon it, the meter may be calibrated in terms of smoke density.

The chart of the recording instrument is calibrated to read in per cent smoke density. The indicating scale may read in per cent or in terms of Ringlemann smoke scales.

The preferred instrument arrangement consists of a recording meter with signal lamps. The chart record may be valuable for future reference in case of disputes, and the signal lights are a guide to the fireman. By maintaining the correct stack conditions, not only may excessive smoke be avoided but heat loss from excessive dilution of the flue gases may be prevented. The smoke meter can become a practical guide in the improvement of firing technique, as well as to give warning of impending trouble with local smoke inspectors.

Zinc Coated Rivet Heads

INTERESTING possibilities for large new uses of hot-dipped galvanized structural steel have recently been developed, with the patenting of a novel method of protecting rivet heads from corrosion.

Thus far, the use of zinc-coated or galvanized members in steel construction has been restricted to comparatively light, bolted structures wherein the individual angles, channels, plates, and other units are first galvanized and then fastened with galvanized bolts and nuts. Hot-dipped galvanized steel has long been recognized as a most desirable material for the heavier types of steel construction because of its excellent weather-resisting properties afforded by the extremely heavy coating of zinc which such material always carries when galvanized. These heavier structures are usually riveted together, and because of the difficulty of protecting the bare rivetheads against corrosion, galvanized steel has seldom been used.

The galvanizing of such structures after assembly is usually impossible because of their extreme size and awkward shape. A further difficulty is that the members are in such close contact that the removal of oxide scale and zinc coating of the rivets is impossible.

In the new method, the individual units of riveted steel structures are galvanized before assembling, joined together in the usual manner with ordinary uncoated rivets, and the exposed rivet heads are then sealed off from the weather after the entire job is assembled in the field. Circular flanged caps, formed of heavy gauge rolled zinc, fit snugly over the rivetheads. The cap is fastened to the galvanized surface of the structural piece through which the rivet passes by means of a continuous ring of solder applied with a specially shaped soldering iron. The caps fit various sizes of rivet heads and have a heavy ring of solder attached to the under side of the cap flange.

Sensitiveness of the Human Body to Vibrations

POWER plant engineers know of the troubles caused by vibrations in the neighborhood of plants, which are felt even at some distance from their source, causing difficulty with buildings, or at least disturbing people. While the effect of vibration on materials is clarified by research because it is somewhat easier to define these effects on strictly inert matter, knowledge of vibration effects on human beings has been missing for a long time. Because of the importance of correct data on this question,

a series of tests were carried out to discover the sensibility of the human body to vibrations. The apparatus was a heavy platform hanging on vertical and horizontal springs to allow vibration in any direction.

A small electric motor with an eccentrically loaded flywheel, mounted at the center of gravity of the platform, produced the vibrations. The frequency could be varied from three to seventy cycles per second. Tests were made on the platform with ten persons of different ages and sensitiveness. The scientists expected to find regions of sensibility to vibrations similar to those which are known for the sensibility to noise.

Dry-Cleaning Machine for Sand and Gravel

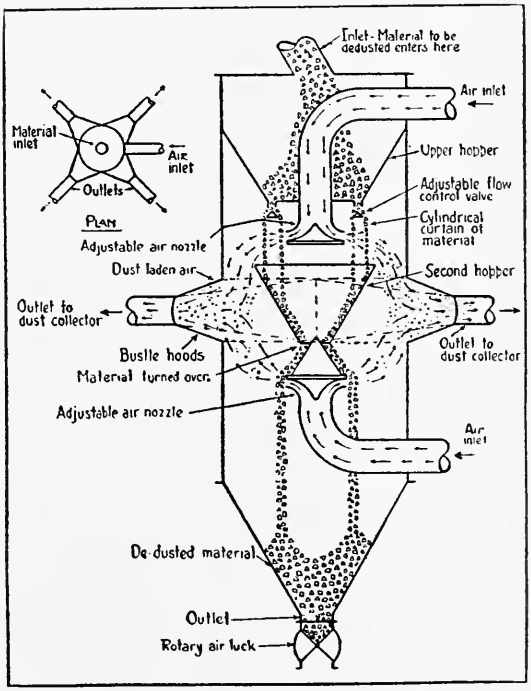
(From Compressed Air Magazine)

FOR the purpose of removing undesirable dust and fines from sand and gravel, an entirely new kind of machine called the "De-duster" has been designed. This machine can handle any material from minus one inch mesh down and cleans it with low pressure air.

The gravel or sand to be "de-dusted" is run into a hopper in the top of the machine. From there it falls through circular feed slots over adjustable flow-control valves that divide the material into two cylindrical curtains dropping on opposite sides of the hopper. At this stage the gravel curtains are acted upon by streams of air admitted from above and issuing from a 2-way adjustable nozzle—the heavier particles falling into a second hopper immediately below the first while the lighter fines are blown through a bustle hood into a dust collector.

The second stage of the cleaning process is practically a repetition of the first and therefore assures the thorough cleaning of the sand or gravel passing through the machine. In the middle hopper the material is turned over and is again allowed to fall down the outer sides of a cone set into the bottom of the hopper. In falling into the bottom hopper the curtains of material are once more subjected to blasts of low-pressure air which is forced upward through a 2-way nozzle. This completes the actual cleaning of the sand or gravel. However, the air laden with the dust and fines is carried into the common framed-bag dust collector where the discarded material is graded and turned out in a dry and usable form.

This machine can be regulated by means of the flow-control valve and the air nozzles so as to remove particles from 10-mesh down to infinitely fine dust. The shell and hoppers are built of quarter inch plate in order to resist the great amount of abrasion to which these parts are subjected.



New building material "De-duster" developed

CONTRIBUTORS' PAGE

BRIEF BIOGRAPHICAL SKETCHES OF OUR AUTHORS

MR. R. S. KENRICK is an Armour graduate in Electrical Engineering of 1922. His article, "Economic Stability, Fallacy or Future Possibility," was written after long observance of general conditions in his capacity as Market Survey Editor, A. C. Nielsen Co., Chicago. Mr. Kenrick analyzes the situation capably and offers solutions for a number of perplexing problems. His article will be concluded in the May issue of THE ENGINEER.

MR. S. L. INGERSOLL is the author of "Stainless Clad Steel for Industry." Mr. Ingersoll is the Vice-President in Charge of Research, Ingersoll Steel and Disc Company. This Company is a division of Borg-Warner Corporation. The article is of especial interest as it follows one of Dr. M. A. Grossmann on "Development of Stainless Steels and the Present State of the Art."

MR. BENJAMIN F. MORRISON is the author of "The Ogden Avenue Improvement." Mr. Morrison is a graduate of Armour, having obtained his B.S. degree in Civil Engineering in 1922. At the present time he is employed with the Local Board of Improvements, City of Chicago. It was through this position that he obtained the data for his article. While at Armour Mr. Morrison was a member of Scroll and Triangle and President of the Armour branch of Western Society of Engineers.

MR. C. A. BUTCHER, author of "Mercury Arc Rectifiers for a 250 Volt Direct-Current Power Supply," is a District Manager of Engineering, Westinghouse Electric and Manufacturing Co. This article was read before the New York City section of the A. I. E. E., at a meeting in November, 1932; it being very well received.

WILLIAM W. LANGE, the author of "True Color Rendering" is a senior student in the Department of Electrical Engineering. His ability to write on this subject is evidenced by the fact that he has been the staff photographer for *The Cycle* for the past two years. As well as being interested in photography, Lange is a member of several honorary fraternities, among them being Tau Beta Pi, Eta Kappa Nu, Sphinx, and Pi Nu Epsilon. He is also the President of the Interfraternity Council.

NORMAN E. COLBURN, JR. is the author of "Illinois Central Lake Front Development." This information has been supplied by the Chief Engineer of the Chicago Terminal Improvement, I. C. R. R. Colburn has compiled this data into its present form. Colburn is the Editor-in-Chief of *The Armour Tech News* and a member of Tau Beta Pi honorary fraternity.

G-E *Campus News*

TAMING LIGHTNING

A crackle, a deafening crash—and a gigantic streak of man-generated lightning leaped 30 feet. Thus, was 10,000,000 volts, the largest artificial flash ever produced by man, discharged at the G-E high-voltage laboratory.

To produce this enormous voltage, a 50,000,000-kw. lightning generator imitates nature. Hundreds of small capacitors take the place of nature's clouds. They are charged by transformers. When the voltage is built up, the capacitors are discharged in series to produce 10,000,000 volts. Sounds simple, doesn't it? However, the power output of the generator—during the infinitesimal period of the flash—is nearly twice that of all the generating stations in the United States.

F. W. Peek, Jr., a Stanford grad of '05, was chiefly responsible for this achievement—incidentally, he is now the chief engineer of the G-E Pittsfield Works. "Lightning tamer," his old classmates would probably call him. And rightly proud of him they should be, for in the field of transients and dielectric phenomena he is second to no one.

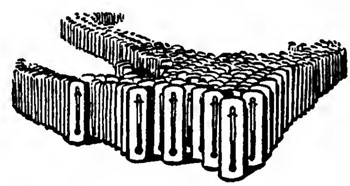
ATOM CHASER

On December 10th last, a mild-mannered scientist stood in the Great Hall in Stockholm and received the Nobel Award in Chemistry for 1932. Then he went skiing with his wife and daughter, seemingly unmoved by being the second American chemist in 31 years to be so honored.

In 1909, Dr. Irving Langmuir, a '03 graduate of Columbia University, came to Schenectady, to the G-E Research Laboratory, to ask questions about tungsten wire, its behavior in a vacuum. He stayed, just "looking around" and wondering why the bulbs of incandescent lamps blackened so easily. He found out, and thus developed the gas-filled lamp. It saves Americans a million dollars every night.

Then he wondered about atoms coöperating with electrons and produced the high-vacuum electronic tube, making possible radio broadcasting, which created an industry. Incidentally, he contributed a new type of welding—atomic-hydrogen.

They call him atom chaser, electron driver. The Swedish Academy of Science rewarded him—not for lamps, radio tubes, or welding methods, but for achievements in pure science. For just "wondering."



25 MILLION THERMOMETERS

You may have heard about our new power plant at Schenectady—the first of its kind ever built. In it there's a 20,000-kw. mercury-vapor turbine. The plant uses mercury vapor for power, the exhaust vapor producing superheated steam.

270,000 pounds of mercury will be needed for the boilers. That's enough for 25,000,000 thermometers. Perhaps you wonder why we don't use water. Well, the new process makes it possible to obtain about thirty per cent more power from coal than heretofore. And we don't expect that those boilers will be refilled.

W. L. R. Emmet, an '81 graduate of the U. S. Naval Academy, is the inventor of this mercury-vapor process. That isn't all he's done, either. In his capacity as a consulting engineer of G.E., he developed the steam turbine from a small beginning to a place of dominating importance, and he first applied electric power to ship propulsion.

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GENERAL ELECTRIC

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MAY, 1933

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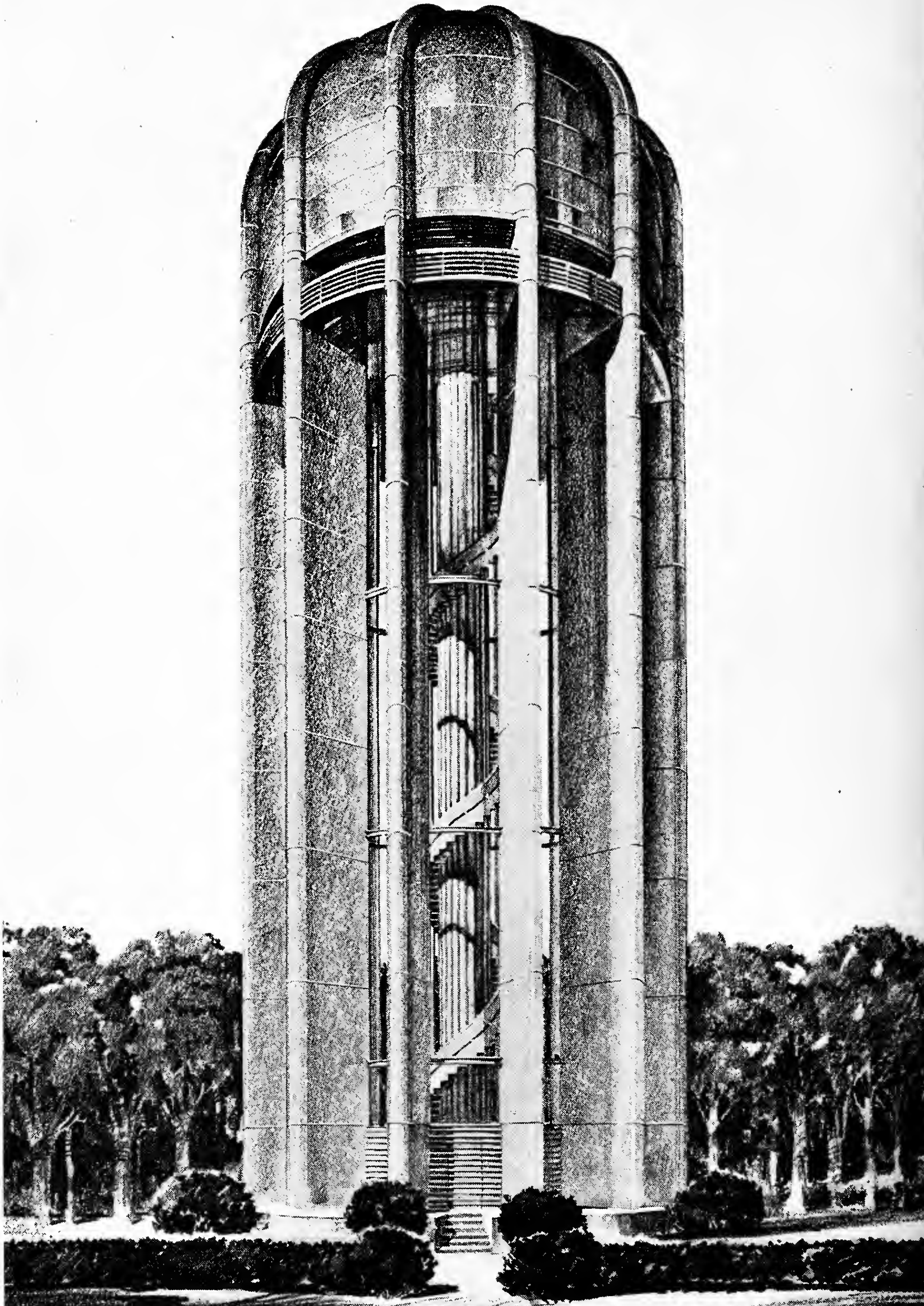
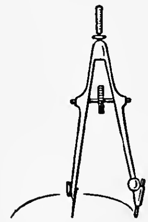


A Modern Water Tower

THE

ARMOUR ENGINEER

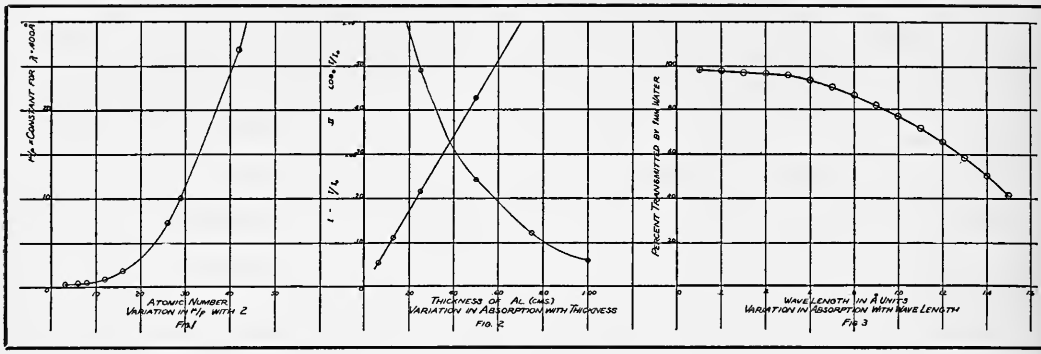
MAY, 1933



X-Ray Absorption, Measurements, and Applications

By PROF. WILLIAM W. COLVERT

SHORTLY after his discovery of x-rays, Reontgen discovered that different materials did not absorb the new rays equally and that the absorption did not depend upon density alone. Various experimenters, independently, reached the conclusion that the absorption was a function of the atomic weight. It was also discovered that a beam of rays which had previously passed through an absorbing material did not show the same degree of change on passing through a second material as it did when passing directly through the second material; and that the effect varied with the thickness of the first absorber. This lead to the conclusion that the rays coming from the tube were not homogeneous; and that absorption was a function of the wave-length, or quality, of the x-ray beam. The variation of absorption with the atomic number, thickness of the material used and the wave length of the x-ray beam is indicated by figures 1, 2 and 3. Data



for figures 1 and 2 were taken from "X-Rays and Electrons" by Compton[2] and that for figure 3 from "X-Ray Technology" by Terrill and Ulrey[9]. The scale used for the absorption is purely arbitrary.

It has been shown that when a beam of intensity I_o is normally incident upon a sample of absorbing material of thickness x, the intensity of the emerging beam, I, is given by the equation,

$$I = I_0 e^{-\mu x} \qquad (1)$$

where μ is a quantity called the coefficient of absorption. If we rewrite the equation in the form

$$I = I_0 e^{-\frac{\mu}{\rho}.\rho x} \qquad (2)$$

ρ being the density of the material, the quantity μ/ρ is called the mass absorption coefficient.

This reduction in intensity is found to be due to two factors; true absorption and scattering. It has been found possible to represent this fact and the dependence of the absorption upon the wave length by the empirical equation,

$$\frac{\mu}{\rho} = k\lambda^3 + b \qquad (3)$$

where λ is the wave length of the radiation, k is a constant for a particular region of the x-ray spectrum and b is a function of the scattering.

A simple arrangement of apparatus for showing absorption is shown in Fig 4. X-rays from the target, S, pass through a slit in the side of the lead container and fall upon the material A. The intensity of the beam emerging from A may be determined by measuring the ionization current and may be compared with the intensity when A is removed.

In some cases it is preferable to use an x-ray film and obtain a more permanent record. The density of the exposed film is compared with the density of the film obtained when the absorber is absent. As such a comparison, to be accurate, requires much more equipment than the first method, the ionization chamber method is often used.

Since the ionization chamber is used in so many x-ray measurements, details of one type are shown in Fig. 5. A collector, A, which consists of a small rod with either a similar rod or a thin sheet of metal attached at right angle, is insulated from the remainder of the chamber by a material, B, such

as quartz, amber or sulphur. This collector is so placed that it is not in the path of the direct beam of x-rays. To prevent leakage of the electric charge between A and the body of the chamber, E, a guard ring, D, is between the two and, when in use, is grounded. C is an insulating material such as hard rubber or bakelite. Windows, F, of celluloid, mica or thin aluminum foil are cemented over the openings in the ends in order that the chamber may be evacuated and refilled with the gas best suited for a particular type of measurement. The entire chamber, with the exception of the windows, is covered with a lead shield which may be grounded.

When in use, the collector with a potential applied is connected to an indicating instrument such as an electrometer. One type of circuit is shown in Fig. 6. Fig. 7 shows some of the details of the Compton electrometer which is often used.

When a beam of x-rays, or other ionizing agent, enters the chamber, ions are produced. Under the influence of the electric field, the ions are set in motion between A and E and the rate of accumulation of the charge on A is indicated by the electrometer. This rate is a proposition of the intensity of the beam if all ions are drawn over. If an absorbing material is placed in the path of the beam, a reduction in the intensity of the beam entering the chamber is at once indicated by a change in the rate of accumulation of charge on the collector.

Since absorption is a function of wave length, accurate determination of an absorption coefficient requires a beam of x-rays at least approximately monochromatic; or a knowledge of the wave lengths and relative amounts of each present. The usual method of obtaining such a beam is by reflection, diffraction or a combination of the two. For this purpose an x-ray spectrometer is desirable. A typical arrangement is shown in Fig. 8; the slits, crystals, electrometer and ionization chamber being mounted on the spectrometer.

A beam of rays from the tube, A, passes through the slit S_1, to the crystal B. If the angle of incidence is adjusted for a particular wave length λ, using the relation $n\lambda = 2d \sin\theta$, a modified beam leaves B and passes through the slit, S_2, to the crystal C. When C is set for the same angle of incidence as B, the beam leaving C is suitable for accurate absorption measurements. The beam leaving C passes through the slit S_3 and into the ionization chamber.

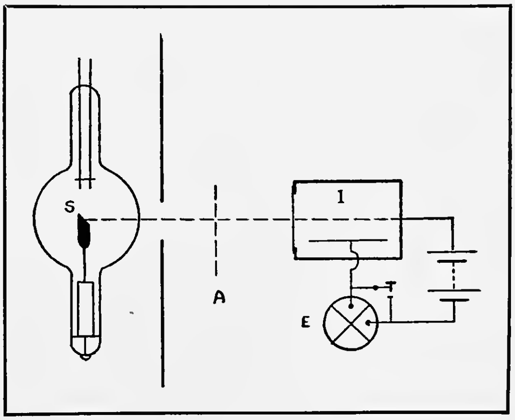


Figure 4

When a determination of the absorption coefficient, μ, is to be made, the following procedure is customary. A charge is placed on the needle of the electrometer and the rate of leakage for the system observed, no radiation being admitted to the ionization chamber during the reading. The times for charging the system over the same range are then observed with and without the absorbing material in the path of the x-ray beam. From these data and the thickness of the sample, μ may be calculated.

As an illustration, consider the following case. Three samples of aluminum were placed in the path of a beam of x-rays of wave length $.631 \times 10^{-8}$cm. The data mentioned as necessary were taken; t_1/t_2 being the ratio of the corrected time without the sample to the corrected time with the sample in the path. The results are shown in the table.

Thickness of Al. (cms)	t_1/t_2	μ	μ/ρ
.0175	.833	10.3	3.81
.0350	.696	10.4	3.85
.0808	.435	10.3	3.81

A comparison with the corresponding value given in Table VI-5 of "X-Rays and Electrons," by Compton[2] shows this value to be high. Reference to this will be made again.

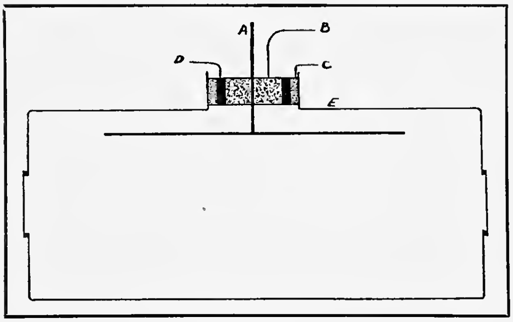


Figure 5

The variation in absorption with atomic number suggests the possibility of using this property as a measure of the relative amounts of substances present in mixtures; or, of determining the concentrations of solutions. As an example of such a use, the aluminum used previously may be taken. These samples of aluminum were found to contain a small amount of iron as an impurity. Let ρ_1 represent the mass of iron per $\overline{\text{cm.}}^3$; ρ_2 the mass of aluminum per $\overline{\text{cm.}}^3$; ρ the density of the mixture; μ_1 the absorption coefficient of the iron; the absorption coefficient of the aluminum; and μ the absorption coefficient of the mixture. The absorption equations may then be written as follows:

$$\mu\rho = \mu_1\rho_1 + \mu_2\rho_2$$

Since $\rho = \rho_1 + \rho_2$,

$$\rho_1 = \rho\frac{\mu_2 - \mu}{\mu_2 - \mu_1} \qquad (4)$$

The per cent of iron=

$$\frac{\rho_1}{\rho} \times 100 = \frac{\mu_2 - \mu}{\mu_2 - \mu_1} \times 100 \qquad (5)$$

Analysis of the aluminum by a chemical method showed .45% of iron.

Using this value and table values of $\mu_1 = 2.0$ and $\mu_2 = 9.91$, the value of μ is found to be 10.8.

An error may be introduced, in such a determination, by an incorrect time observation. Particular care must be taken in making this reading when, as a result of an intense x-ray beam and small absorption, the time is short.

One method of reducing this uncertainty will be indicated.

Since $I=I_0\, e^{-\mu x}$ for a sample of thickness x, for a sample of thickness 2x, $I_1=I_0^1 \,. e^{-2\mu x}$

If I_o remains constant, we may write

$$\frac{I_1}{I}=e-\mu x$$

But
$$\frac{I_1}{I}=\frac{t}{t_1}$$

Therefore
$$\mu=\frac{-\log_e\frac{t}{t_1}}{x}$$

Similarly, if samples of thickness (n-1) x and nx are used

$$\mu=\frac{-\log_e\frac{t_{n-1}}{t_n}}{x} \qquad (6)$$

By this method the time ratio t_{n-1}/t_n remains constant and the average value for a series of samples of thickness x,2 x,3 x, etc., may be used. This method assumes a constant I_o but even when I_o shows small fluctuations, the effect of such may be reduced by taking over a period of time, readings in the same order, with each of a series of samples.

Glocker and Frohnmayer[4] have developed a method of chemical analysis in which the intensities on the sides of an absorption edge are used. The values I_1 and I_2 on the sides of the edge are determined. The relation of the ratio of these intensities to the amount of the element under investigation is given by the equation $I_2/I_1=e^{-CP}$, where p is the mass of the element, measured in grams per square centimeter, which is exposed to a beam of x-rays one square centimeter in cross section. The constant, c, is the difference between the mass absorption coefficients on either side of the edge and may be determined experimentally or may be calculated from absorption laws. Values for c are tabulated for a number of elements in Clark's[1], "Applied X-Rays." Using such a method, Hevesy[5] shows results on the determination of the amount of barium chloride in solution which vary in accuracy from 2% to 25%. As the amount of material in solution increases the accuracy of determination increases.

Hevesy[5] also gives rather complete details of a method of chemical analysis which depends upon a comparison of line intensities and he mentions the fact that by absorption methods impurities present in the ratio of 1 to 10,000 or in some cases 1 to 100,000 may be detected.

The commercial uses of absorption measurements are exceedingly varied.

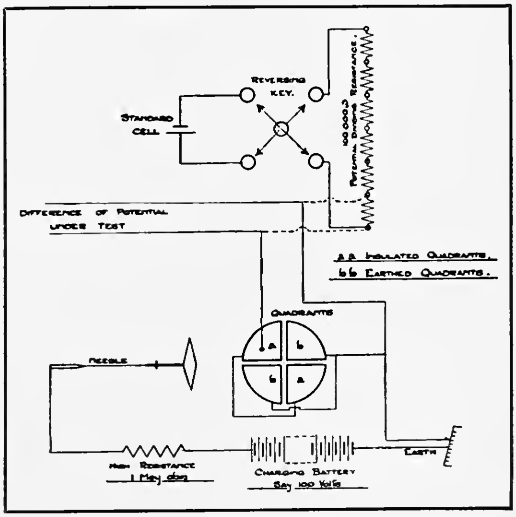


Figure 6

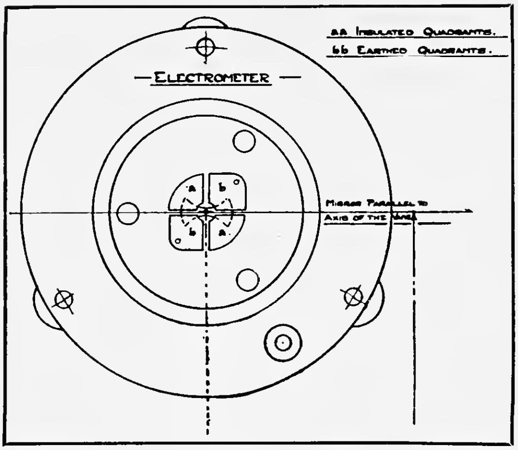


Figure 7

One plant will use this method for determining the uniformity in thickness of samples of material; another will use the same method for detecting porosity or other variations in structure.

Comparatively recent development of 300,000 volt equipment for continuous operation has extended the range of usefulness of this method of investigation. R. E. Hiller,[6] in a recent issue of the *General Electric Review,* describes an installation for testing the welds in steel boilers with wall thickness up to 4½ inches. In an actual test, the weld in a mercury boiler drum with a 4⅛ inch wall was examined at the rate of two feet per hour. A complete examination of the weld of a 3 inch wall could be completed in the same time. Mr. Hiller[6] also says, "When tube design will permit operation at higher voltages, this thickness limit will again be materially increased and production x-ray examination of steel up to six inches in thickness may be expected."

That the prediction as to future increases in limits of steel investigation is well founded may be inferred from recent x-ray tube developments. Lauritsen[8], at California Institute of Technology, has operated a tube at 600,000 and at 1,200,000 volts. Coolidge[3] has designed an outfit for the Memorial Hospital, N. Y., to operate at 900,000 volts and Mercy Hospital in Chicago is installing similar high voltage equipment of even greater energy rating. Tuve[10] and associates at the Carnegie Institute in Washington have operated a tube at nearly 2,000,000 volts; and Lange and Brasch[7] of Berlin surpassed this by operating for a short time at 2,600,000 volts.

It would seem as if this limit would be sufficient for most purposes. But, in the words of Clark,[1] "In Berlin a new 7,000,000 volt surge generator is being built to be used with a Lange-Brasch tube. This tube will be devoted to cancer research and physical experimentation. It is planned even to impress upon such a tube the high potentials of the natural electrical discharges in thunderstorms (these

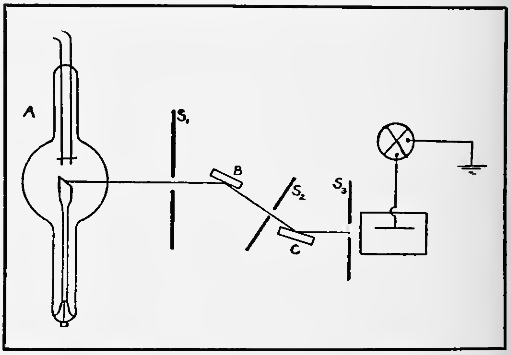


Figure 8

experimenters have already measured discharges in the mountains of 16,000,000 volts); if successful, there will be produced gamma rays equivalent to a hundred thousand grams of radium, which is at least a thousand times as much radium as there is now available." When we consider the fact that rays from a 3,000,000 volt tube will penetrate a yard of lead, the time for the examination of steel even thicker than six inches, as routine procedure, does not appear to be very remote.

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Perspective and Entourage

By PROF. HARRY H. BENTLEY

MEN who graduate from schools of architecture are of two general types. In the first, mental growth may be likened to the physical deposit of one strata of knowledge upon another—accumulations of theory and fact which may be made accessible for future use by a sort of sinking of shafts and drilling of cross-drifts. The resultant architect may become an industrious and reliable worker, but it is not from his ranks that great leadership and outstanding achievement will spring. In the second type, mental equipment has not only been physically augmented, but has been chemically transformed into a magic talisman with which its possessor may make new and unsuspected uses of acquired knowledge.

Starting at "scratch," can we isolate and define the qualities that will ultimately produce the first type of man or the second? Is it possible for a student to believe with confidence and satisfaction that he is of the second category, or must he hopelessly see himself assigned by powers beyond his control to the other less promising and versatile class? Modern psychology, with all its earnest effort to prod deep into questions of heredity and inborn endowment, has found no answer nor formula, nor can we hope that such questions, entering as they do into the realm of the abstract and intangible, will ever be soluble by chart or graph. When we come to environment, however—and what is an architectural course but an important period of environment—we enter a realm where tangibles rather than intangibles prevail, and where the individual's control of his own destiny may become effective. His inheritance from historic and prehistoric ancestors is a fixed quantity, a set of tools that have been shaped and forged without his approval or assent, and these tools, such as they are, must be the equipment with which he begins to build his career. To polish and perfect those tools, to use them for making other instruments of greater precision, is the problem of education. The problem belongs much more to the student himself than to the school organization and staff of instructors, to whom he can look for no more than assistance and guidance.

Early in his course, the student of architecture studies the principles of

perspective, an application of descriptive geometry which enables him to stand back and see his problem from a distance, or from high above, if he desires. From his chosen station-point, he gains a comprehensive view of his problem as a whole and in the round, checking errors and finding new and unexpected possibilities that too close application have kept hidden. He also studies the presentation of *entourage,* placing his design in a setting of organic and inorganic life, sky, clouds, trees, and human beings, and transforming it from mechanical drawing into reality.

The student, as well as the practising architect, may find profit in occasionally subjecting the whole problem of an architectural career to mental tests of perspective and *entourage,* taking his station-points at greater and greater distances, until his picture includes the whole of architectural development against a background of human activity from the far-away dawn of life. He may find it useful in his application of these tests to include the super-Einsteinian power and remoteness of vision that Camille Flammarion, the French astronomer, once described in a moment of fantasy. A disembodied spirit is pictured as leaving the earth at a speed greater than that of light, thus enabling him to overtake light-waves propagated by past events, which he is thus enabled to see, in reverse order, as far back as the infinitely distant and cataclysmic *eos* of the universe.

This suggestion is no more than a plea for a philosophic attitude towards architecture on the part of the student and architect. Philosophy may seem a remote and academic idea to the vigorous student, or to the practical architect struggling with full-size details and shop-drawings: but what is philosophy? It has been defined as speculative knowledge, or the science of principles, or the matter, form, causes, and ends of things in general. We all have a tendency to take only minor interest in things remotely connected with our activities, and to reserve our lively interest for things that have a very direct bearing upon what we are doing. To speak of the philosophy of architecture may, at first mention, suggest dry and academic speculation, but if the term is seen to mean the matter, form, causes, and ends of architecture, it comes directly home to every student and architect. If the deliberate cultivation of a philosophic attitude towards architecture may tend to promote the individual from the static and unimaginative class mentioned at the beginning of this article to the dynamic and imaginative class of the same paragraph, the practical value of thinking habits that will create such an attitude will need no advocate.

To prove that such effort will produce such results is a matter for individual demonstration, and like certain discoveries in mathematics and science, the proof must follow the initial acceptance and application of

the principle. The processes are too slow and gradual to be worked out in a laboratory or subjected to visible analysis. It may be possible, however, by scrutiny of past and present progress, not only in architecture but in other fields of art and science, to build up a preponderance of probability that will make initial acceptance easier to the skeptical.

As an example, suppose we take the tendency of today that is known as modernism in architecture. Its manifestations are apparent to even the casual observer as he walks about our cities. Everywhere he goes, he sees buildings and decorative treatments that are very different from those of the near past. In the business centers, instead of great cubical masses pierced with windows and topped with flat lids echoing the flatness of the ground, he sees shapes that have been moulded into contours like great pieces of sculpture, with broken sky-lines that spurn the horizontal earth and soar from it into the clouds. As he rides along Chicago's lake front, he sees the buildings of the Century of Progress springing up overnight like mushrooms of a strange new species. The tiny shop-front, or club lounge, or tea-room presents an arrangement of form and color that speaks a new language, discarding the older vocabulary of column, pilaster, and cornice.

The advent of this new spirit has resulted inevitably in a certain contempt, both in student and practising architect, for the forms of the past, and in fear that the designer will be pronounced reactionary and old-fashioned unless he clothes his ideas in forms that differ in every way from those of older days. So strong is this desire in the unimaginative designer to avoid use of familiar traditional forms that it results, both in *atelier* and office, in a willing enslavement to forms created by more able modernists, and he "jumps from the frying-pan" of copying Vignola "into the fire" of copying Le Corbusier or Van De Rohe.

What attitude will the intelligent student take towards this tendency? By applying his mental tests of perspective, *entourage,* and remote vision, he will see that it results from a belief that modern problems are new and revolutionary, and that they therefore demand the invention of new and original forms for their architectural expression. Subjecting this belief to the same tests, he may come to the conclusion that it is partly true and partly false. Certain of our activities today are in the direct line of tradition and others are not. The design of a filling-station, or a grain-elevator, or a planetarium can not be based upon precedent or traditional form, but many other contemporary buildings, the church and the dwelling-house, for example, satisfy needs that vary little from those of times past. Are the problems of a home-loving family desiring its own roof over its head very different from those of ages ago? That they are not may be proven by the fact that a New Yorker or a Bostonian can go

out into the country thirty or forty miles from the city, buy a fine old Colonial house, and with little more change than the installation of electricity, central heating, and modern plumbing make it into a house that will solve his living problems to his entire satisfaction. Even in the realm of mechanical equipment, the uninformed modernist may have an exaggerated sense of recent change. The wealthy Aegean of pre-Greek civilization built in Cnossus and Tiryns houses containing bath-rooms and running water, and the Roman of the late republic and empire heated the principal rooms of his house with warm air conducted from a central heating-plant through tile pipes.

The philosophically minded student may subject opinions based upon new structural methods and materials to these same tests. Steel for structural shapes is new; so is its use for giving tensile strength to concrete, although bulk concrete reinforced with masonry arches was used with skill in Rome two thousand years ago, as in the Pantheon and the great baths. Skeleton construction is new only in its use of steel and reenforced concrete: the Gothic builder developed in stone a system of skeleton construction, concentrated load, and balanced thrusts that reflected the highest degree of engineering skill.

Nor is the advent of steel, reinforced concrete, and other materials to be viewed as a necessary and total displacement of other products that have been used since time immemorial. The analytical student will see in the architecture of Greece, not merely an assemblage of column and entablature, decked out with triglyph and metope, but a high development of the principles of trabeated construction expressed in stone, created by builders who not only knew the bearing capacities and spans of stone lintels, but who possessed along with their technical knowledge a sensitive feeling for proportion and beauty. He will see in the almost total absence of arch and vault from Greek architecture, not ignorance on the part of the Greek builder, but evidence of climatic and social factors which caused the Greeks to hold their assemblies out of doors and have no need for great enclosed and covered spaces. He will see in the great vaults of the Roman baths, on the contrary, the problem presented when an imperial metropolis desired to provide heated shelter for the indoor recreation of thousands of its citizens. He will see in the gradual transformation of the wood-trussed basilican church of the early Christians into the stone-vaulted marvels of Rheims and Amiens the same desire for fire-proof construction that prompts the modern builder to eliminate fire hazards.

Cultivation of a philosophic attitude towards architecture must therefore mean thoughtful and intimate knowledge of its history and development. The architecture of any past time will appear in the light of its response to the needs of human beings of

that time—their manner of daily life, their religious worship and ritual, their systems of political assembly, their games and recreations, and their methods of education and government administration. These diverse activities will be seen as influences that shaped and moulded the methods for combining available materials into buildings for sheltering the human participants, and this combination of materials into a system of construction will prove, in the last analysis, to be the actual architecture of the time. Guadet, in his "Elements and Theory of Architecture," a work of inestimable value that should be much better known to American students of architecture, has emphasized this identity by saying, "It is a great misfortune that our language possesses these two words—*architecture, construction*—where there should be but one, and that the first." The detail and ornament of a particular period, by such appraisal and analysis, will be given its proper value and no more, and it will become evident that a design can not be made Gothic by the mere addition of buttresses, pinnacles, and crockets. Detail will have somewhat the same significance as the flint utensil dug out of the floor of a cave inhabited by human beings of the glacial ages: it will be a key and guide to more significant and important deductions and discoveries. To quote Guadet again: "My role is not to teach you the decorative treatment nor the characteristics of the mouldings in a particular period; our task is to study one architectural conception, then another, then still another . . . and to seek the *Why.*"

This quest for fundamental principle should not be, and need not be, a dry and academic study of the past, nor should it foster the exaggerated and conservative reverence for tradition that has characterized the oriental civilizations. The modern archæologist, typified in men of such outstanding achievement as James Henry Breasted, has made his greatest contribution to modern thought, not in the extent of his excavations and the erudition of his conclusions, but in the breath of life that he has breathed into his finds, in the poetic and intelligent imagination with which he has magnified the meager relics of early man into a world peopled with beings whose incoherent aspirations and primitive achievements make them brothers to us of today.

We are able to see that the visible decay of crumbling temples and the apparent destruction of the once powerful nations that built them have less of ominous portent in reflecting that the precious essential residue of civilization has never been destroyed, but has always been preserved and transmitted to other hands for future use.

Air Conditioning for Radio Broadcasting Studios

By BERNHARD H. E. LOESCHE

DURING the past several years, air conditioning has taken an extremely important place in the mind of the engineer. The factors necessitating the development of a suitable means of controlled ventilation have been many in number. Outstanding among these were the knowledge of the poor heating efficiency, derived when natural means are employed, and the inability of workers to perform at the best of their abilities due to an uncomfortable environment.

The conventional ventilating fans have been in use for some time but they in themselves present no means of controlling the temperature, humidity or cleanliness of the air. They are, of course, adequate for the sustenance of life in otherwise uninhabitable places, but they furnish no more than fresh air, untreated.

The rapid development of radio to its present high status has perhaps influenced the recent discoveries in air conditioning more than anything else. In order to secure a maximum in radio transmission, the studio from which the program is emanating must first be entirely apart from the world without. If a natural ventilation from outside sources must be depended upon, this end cannot be accomplished as windows become necessary. Air conditioning must therefore be developed to a high degree to serve this industry if no other.

The presentation of a favorable method of merely circulating the air is insufficient. With this must be embodied a means of washing, filtering, dehumidifying and close temperature regulation. Radio is a very costly industry, employing high salaried artists. In order that these artists may present their programs to the best of their abilities, the studios must be of just the proper temperature and humidity to satisfy their individual needs. The exhilerating comfort of a fine studio on a sultry afternoon in mid-summer is beyond an expression of words. This effect is felt by the performing artists and their work is done far better than would be possible were they concerned with a feeling of discomfort.

The instance here cited is that of the proposed system to be installed in the new National Broadcasting Company's New York studios. They are now in the process of construction in the seventy story office building, the dominant figure of Rockefeller Center. This system is of exceptional interest because of its high caliber, exceptional planning and the intensive effort on the part of bidding companies to present the finest of everything. The benefit of latest developments in equipment, methods and materials has been derived and made use of, yielding a net result that all equipment signifies the ultra-modern.

The enterprise embodies the second to the eleventh stories inclusive. This space will be occupied by twenty-seven major studios, offices, and all the other necessary auxiliaries for continuous broadcasting over several networks. The studios range in size from 3,000 to 325,000 cu. ft. They are all two stories in height, of which the first floor is the active level for the artists, together with the control rooms, and the second floor is for observation purposes.

Typical Broadcasting Studio

In designing, six points required coverage, namely, maintenance of comfort in studios proper, artist's space and public space; sound proofing and prevention; ease of control; flexibility; avoidance of breakdown emergencies as far as possible and facilities for easy rectification; operating facilities.

A floating wall, floor and ceiling made of the finest sound insulating materials available create rooms within rooms. The dead air space between the acoustic material makes the studio absolutely soundproof but is thermally equivalent to about ten inches of cork. High powered illumination is a necessity and the heat thus produced, coupled with that of as many as 100 artists at a time, would produce a condition which could not be borne in this heat-proof box were it not for air conditioning.

The system must be flexible so that rapid changes can be made, but this must be so accomplished as not to dissatisfy any requirement of sound prevention. All studios and observation rooms are under individual automatic control while other spaces are grouped on a functional basis. Five different control methods are used depending on the requirements, namely, return air pneumatic, supply air pneumatic, room thermostat pneumatic, room thermostat electric and manual outlet. Windows are provided only in the offices.

The most prominent breach be-

tween this and the average conditioning installation is the necessity for extreme soundproofing. If the system were noisy, it would be worthless, even though its mechanical operation might be perfect. This requirement dictated the size, shape and location of all ductwork. The studios have been designed to extract so much ordinary noise that the seemingly negligent sound of air rushing through a duct would sound intolerably loud. The super-sensitivity of the modern radio microphone is so great that it will pick up sounds undetectable to the human ear and amplify them.

Since the studio soundproofing was more efficient than ever before accomplished, the duct soundproofing must be also proportionately better. Special tests were made on various materials and means of application at forty different frequencies in order to secure best results.

The need for treatment can be traced to two main sources, namely, the lowering of the isolation value of the construction because of its being pierced by the ductwork and the originating of sounds within the ductwork itself. A resolution into a more detailed classification follows:

1. Apparatus noise conveyed through ducts.
2. Sounds created by air friction on sides and over edges.
3. Sounds created by turbulence due to high velocities.
4. Sound transmitted by the sheet metal of the duct.
5. Foundation vibrations of the apparatus.
6. Lowering of sound insulation value where ducts pierce the construction.
7. Transmission of sound through ducts connecting one studio to another.
8. Vibration in the piping.

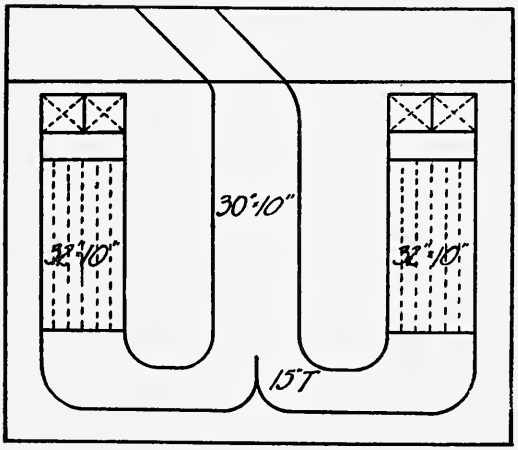
From these points it may readily be seen that sound reduction is equally as important as air distribution. The basic design provides for serving the studios with equipment exclusive from that of the remainder of the installation. Five dehumidifying units are provided for the studios and five more for all other places. This division was made primarily because of the difference in sound level requirements. The studio ductwork is therefore segregated from all others and may therefore be separately acoustically treated. No interference is thus possible from other sources not so well attended.

The apparatus used for the actual conditioning of the air is of several parts. A battery of refrigeration units is installed in the sub-basement. These units have a combined maximum cooler load of 900 tons. The condenser water heat is rejected to a cooling tower system atop a neighboring building which may handle 500,000 cu. ft. per minute. The dehumidifiers, in which the chilled water is sprayed, are located on the 11th floor. They employ 30 fans with a total supply circulation of 300,000 cu. ft. per minute, and serve 300 rooms, all

separate and distinct from one another; 150 supply and return air ducts penetrate this room. Careful planning was necessary for a centralized system of this type. The result is the most complex conditioning assembly within the confines of a 25,000 sq. ft. room.

Convenient facilities for the operation of so great a plant are of primary importance as instantaneous adjustment is deemed essential. All controls are in ready access in a single glass-enclosed control room. One-half of the 78 return air ducts will be provided with direct remote control. Electric recorders will provide a permanent record of all important conditions. One huge control board will contain the complete assemblage of controls from all studios. Thus, full supervision is possible from one point.

Each supply and return air duct at its outlet must be extended and turned back in the manner shown in the accompanying figure. This must be done in order that an 8 ft. straightaway



Method for installing ducts

duct be obtained in which to place the sound absorbing material.

The fans used were selected both with respect to quietness and performance, since they operate immediately above several of the studios. Part of the system uses partial volume control operating from a constant pressure chamber. They discharge against a changing resistance resulting from changing volume. The remainder of the fans are designed to operate under a constant volume and resistance delivery. All fans operate on the dehumidified air suction side.

The acoustical material used as an interior finish, being designed solely for its sound properties, is quite porous and therefore subject to rapid smudging. In order to eliminate the usual unsightly streaking, special ceiling plaques were designed. The outlets in all cases are concealed by special grilles or plaques which add to the beauty of the room rather than detract from it. Nothing has been spared in making the entire unit a beauty spot.

In designing the sound insulation, special sliding panels were placed in the walls in order that some of the sound absorption might be removed at will. This was done in order to yield a means of compensation for large crowds which might be in the studio. If too much of the sound is absorbed, the music is rendered dull and lifeless. The floor and walls float on specially constructed springs, which do not transmit vibrations. The floor covering adds no sound absorptive value.

In designing the New York conditioning system, all the experience obtained in operating the Chicago studios and others was combined with most recent developments and superb engineering genius to create the finest system of its kind in the world. No item of expense was spared to achieve this end. The system is extremely complicated and the requirements the most exacting that could be imposed. It is also one of the most extensive air conditioning developments of any kind ever constructed under one contract.

Economic Stability, Fallacy or Future Possibility

By R. S. KENRICK

Part Two

BUSINESS depressions in the United States, since the beginning of the present century, have successively reached lower and lower depths. This can be verified by inspecting any of the generally accepted charts of business activity such, for example, as the "Annalist Index of Business Activity." This trend toward "bigger and better depressions" has alarmed some folks who feel that this country cannot withstand any more such severe shocks without a breakdown of our present capitalistic system. Possibly their fears are well grounded, but it is more important at the moment to inquire why each succeeding depression dives to a lower bottom.

It would appear that depressions have a way of improving their technique so that more purchasing power is obliterated by each succeeding depression. Assuming that the Annalist Index hits a final bottom of 52.0 during the current movement, the same index may plunge to a new record bottom, possibly 42.0 or thereabouts during the next downswing. What can we do about it? Students of economics have noticed for some years past a very decided secular trend in the rising unemployment figures. This unemployment kept right on increasing during the years from 1921 to 1929 and has been attributed by several competent observers to the increasing mechanization of industry and greater efficiency of industrial management.

In other words, industry has found ways to increase the productivity of the individual worker. This increased proficiency in output has not been matched by an equivalent increase in total consumption of manufactured goods. As a result millions of men and women have been assigned to the "army of the unemployed." Many of these people find new work, but the cold statistics tell us in no unmistak-

able terms that the secular trend in unemployment is upward.

A contention is that unemployment caused by technical changes in industry (including organization changes brought about by mergers) is the reason why depressions have a way of plunging to lower and lower depths. As we become more efficient we manage to throw more and more people out of employment during a deflationary business movement. Hence, consumption and production slow down to lower rates.

As already pointed out, there is a natural tendency to divert too much purchasing power into capital goods during a rising movement. And the tragic part of it is that the trend toward greater mechanization of industry (which means purchase of more capital goods) accentuates this diversion of purchasing power into capital investments. It seems to possess all the mechanism of a vicious circle.

No capitalist will voluntarily provide the funds for a machine improvement, unless he finds that the investment will show a saving in operating cost sufficient to pay a handsome return on his investment. In practically all cases the major saving is a labor saving, which means that one or more men are dropped from the payroll because total output cannot be boosted enough to warrant retaining all the employees who were on the payroll before the improved machinery or processes were installed.

But, some one will ask, "How about elasticity of demand? More efficient production methods mean lower prices and lower prices will increase consumption to such a higher level that nobody need lose a job." Well, before going any further, we have plenty of statistical evidence that technological unemployment is real and not imaginary. Moreover, it slowly increases in magnitude from year to year. Let us investigate the theories advanced by certain men who attempt not to see any permanent technological unemployment.

These men tell us that everything depends upon the "relative elasticity of demand." There are just three sets of possibilities, namely:

> (1) The quantity demanded may increase in the same proportion as that by which price is diminished. Demand may double if price is halved.
> (2) The quantity demanded may increase in a greater proportion than that by which the price is reduced. Demand may triple if price is halved.
> (3) The quantity demanded may increase in a smaller proportion than that by which price is reduced.

The economist describes these three situations as elasticity of demand respectively equal to unity, greater than unity and less than unity. But before there can be any consideration of elasticity of demand the price must be lowered. Does it always follow that the price is lowered? Not by any means. For example, in the railroad industry many labor-saving improvements have been put into effect but there have been no general decreases in freight and passenger rates. How then can

elasticity of demand come to the rescue of the ex-railroad man?

Now in regard to those situations where elasticity of demand is equal to or greater than unity, it is evident that if many such conditions actually existed in our industrial world, nobody would be talking about technical unemployment, because, in fact, we would have to search pretty diligently to find it. The unemployment would be corrected before even the most capable statisticians could locate it. Of course, free competition will work for lower prices in the long run and this is probably a factor bringing about the needed correction when business gets into high gear.

As a man's income increases, he devotes a progressively smaller proportion of his income to purchasing the necessities of life. Production of food affords an excellent example of this trend. In 1880 the farmers were 42% of the total workers, but in 1920 the percentage of farm workers had fallen to 27%. The 1930 census shows that farm workers account for about 22% of our employed people. Thus within a half century, the number of farm workers needed to feed a given population has been cut approximately in half.

Similar conditions seem to govern the production of most standardized goods. The increase in individual output has not been accompanied by a corresponding increase in the total quantity demanded with the result that labor displacement has been appreciable.

Now those who rush to the defense of these technical displacements argue that when men are being squeezed out of one type of business (such as farming), purchasing power formerly expended upon the products of this industry is transferred (in full) to other industries and builds up more opportunities for work there. It is assumed, of course, that the producers who save in labor, cut the prices of their goods so that if the demand is not elastic there will be purchasing power released which can be expended upon goods of other types. This would increase the demand for such other goods and force these industries to add more men. And, assuming that the labor cost is the only cost (which is not true), the purchasing power transferred to other industries would bear the same relation to the number of workers laid off as the total purchasing power of that industry bears to the original working force.

It is further argued that the weekly average output per worker (in dollars) is the same in all kinds of businesses. This assumption is ridiculous because we have plenty of statistical evidence showing that the value of output per worker varies considerably from industry to industry. This variation is due to many factors, but one of the important causes is the differences in capital investment per worker. Compare, for example, a large electric power system with a cotton plantation,

or a garment factory in a small community.

By such reasoning it is deduced that new opportunities for employment are built up exactly in proportion as the old opportunities shrink. "For every man laid off a new job has been created somewhere, and the ratio between monetary purchases and employment is still the same as before." It is only necessary to provide a clearing house to facilitate these occupational transfers. "It is clear, therefore, that permanent technological unemployment is impossible."

Probably the greatest fallacy in the foregoing line of reasoning is the belief that our purchasing power is a fixed quantity, independent of the percentage of unemployment existing at any moment. These writers argue that where elasticity of demand is less than unity, the money not spent by consumers on the original product will be transferred to other commodities. Thus the "unused purchasing power" will ultimately afford employment for those displaced from the industry where the increase in production originally occurred.

The truth is that our national purchasing power is not and never has been a fixed quantity. It varies directly with the grand total dollar volume of output of all our industries. Hence, all of those industries where elasticity of demand is less than unity will generate less purchasing power as technological advances reduce employment within them. There will be less money spent by consumers on these products. And, of course, these consumers, as a group, will have less to spend because unemployment has weakened their consuming power.

There is no use trying to avoid the plain fact that every person is both a producer and a consumer. No magic means has yet been found to maintain the purchasing power of unemployed men and women. Hence it follows that the term "unused purchasing power" is nothing more than an economic ghost. It exists only in the imagination of those observers who, like the ostrich, bury their heads in the sand so as to do a better job of observing.

After all there is plenty of bona fide evidence that technological unemployment is a reality and not the plaything of theoretical economists. The problem is a distressing reality and will not be solved by attempts to ridicule its seriousness.

Those who deny the possibility of permanent technological unemployment are ready to admit, however, that it takes time for occupational readjustments to be made, and that during this period many individuals have to suffer. The well being of large numbers of people is impaired by these "temporary upsets" which are completely ignored by some economists who profess to have a long-term viewpoint. The chaotic situation is clearly demonstrated by several excellent unemployment surveys made within the last five years. In each case, workers

were interviewed who had been discarded because of technical or merger changes in industry. The purpose of such studies was to determine the facility with which these workers found re-employment.

In Dr. Lubin's survey, 45.5% were still unemployed at the time of investigation. Among these former workers, 76% had been unemployed for more than two months, 41% for more than six months, and 19% for more than nine months. Among the group who found re-employment only 12% had found work in less than a month, while 72% had been unemployed for over two months before placement. Over half (56%) had been without work for over three months, and 24% had been out of work for more than six months.

The other surveys revealed similar conditions, but since many of the workers in each survey group were still unemployed when the investigators interviewed them, the full losses had not yet been realized. It is safe to assume that still further time was lost before these men finally obtained work. It is also probable that some of the displaced workers over 45 years of age would never again find employment because of the age limit drawn by many industrial managers.

Another important disclosure is that even when labor is re-employed it is frequently at a lower wage than was secured in the old job. Many times the work obtained is less satisfactory than the former work. In Dr. Lubin's study 48% of the re-employed workers received less than formerly, 27% received wages equal to those they had formerly received, and 19% received greater wages than before. On the whole the group had certainly lost ground. In Myer's study 46% were earning less, while 30% were getting more money. In Clague's survey over two-thirds of the workers were receiving less on the new job than on the old job, the individual losses in some cases being very substantial.

The problem is well summarized by Paul H. Douglas, professor of economics at the University of Chicago: "While a given set of workers may not be permanently unemployed because of technical progress, there is likely to be a transitional period of unemployment of considerable length and more workers will be lower paid at the new jobs they will find.

"In the past the sufferings of the displaced workers have been either ignored or accepted as inevitable. This we cannot permit in the future. It is but just that society should take steps to lessen the loss which innocent workers suffer from such improvements, and that adequate provision for these workers should be one of the charges upon the net fruit of progress. A society which shows such extraordinary competence should surely be able to devise the ways and means by which this loss may be minimized."

It is thus evident that the greater use of machinery must increase our unemployment problem, unless we

take steps to maintain about the same division of the income dollar as existed prior to the machine installation. Mechanization of industry has proceeded so rapidly in recent years, because many industrial managers found it possible to obtain a larger slice of each income dollar for profit, ignoring the fact that labor's share of each income dollar was less as the result of such technical changes. Such a condition cannot continue indefinitely, and that is one reason why so much of the efficient machinery today is not earning any return on capital.

Hourly rates of wages were not decreased; in fact, in some plants they were increased. However, from an economic standpoint, considering the welfare of the country as a whole instead of some particular industrial unit, it is evident that management and capital succeeded, temporarily at least, in obtaining a greater percentage of the income dollar by virtue of the extensive mechanization of industry. Obviously this situation, not readily apparent at the time of our greatest interest in machine development, resulted in an increased diversion of purchasing power into capital goods.

The whole problem reverts back to the degree of diffusion or concentration of purchasing power. Technical improvements in industry have a tendency to concentrate purchasing power into fewer hands and for this reason they aggravate the ups and downs of the business cycle.

In any discussion of factors affecting the stability of business must be included an analysis of the influence exerted by our foreign trade. Much of our former prosperity was due to heavy exports from the United States to assist in the rehabilitation of post-war Europe. Lack of purchasing power did not prevent these countries from buying our goods. Our internationally-minded bankers stepped into the business scene at this point and with customary deftness negotiated long-term credits to our foreign customers so that they could buy from us.

The bankers were not left "holding the bag"; they peddled foreign bonds in this country in order to raise the funds Europe needed to get our goods. And everybody was happy, the bankers particularly because rumor has it that they received rather princely commissions for their efforts to promote world trade. A glance at current market quotations on foreign bonds might cause one to be skeptical about the ability of some of these foreign debtors to meet their obligations. Credit is certainly a wonderful invention.

Most people recognize the fact that exports of goods to foreign countries increase our national purchasing power. The goods are manufactured in this country and consumed through the expenditure of foreign purchasing power. Importation of goods from foreign countries has the opposite effect on our economic machinery. Foreign goods compete with those of our own manufacture in our domestic

markets. We must expend part of our national purchasing power to import goods.

After these preliminary generalizations, it is obvious that every country should try to export more goods than it imports. But so far the idea has never been completely successful. Any country enjoying a favorable balance of trade creates more purchasing power in exporting than it expands in importing. This excess can be employed for purchase of additional consumer and capital goods in its domestic markets.

It is not possible to build up purchasing power in one country by exportation of goods to other countries over a long period of years, without at the same time building up purchasing power in foreign countries through importation of their goods into our country. After all, goods can only be exchanged between countries when there is present sufficient purchasing power to effect the exchange. In this respect it follows the general plan of our interstate commerce.

Our importations of foreign goods create the purchasing power abroad to enable us to export surplus goods to foreign markets. The only way to develop purchasing power is through the production of goods and services. There is no magic way to circumvent this necessity.

Temporary stimulus to exports by long-term credits to foreign buyers and changes in tariff barriers all exert an influence on the tempo of our business operations. Hence, stability can never be hoped for until foreign trade is established on a more economic basis. This will mean less political meddling than has been the fashion heretofore.

Can we obtain a greater measure of economic stability? To answer that question we must first find out whether Americans are willing to give up any of their traditional economic freedom for the sake of greater security for society as a whole. We know definitely that the general welfare can be promoted by stopping certain abuses of our glorified individualism; but will we pay the price? Therein lies the answer.

THE TECHNICAL BOOKSHELF

REVIEW OF NEW BOOKS OF ENGINEERING AND SCIENCE

Fundamentals of Instrumentation

By M. F. Behar

(Instruments Publishing Company)

AMONG the latest works on the use of instruments we find that of Mr. M. F. Behar taking a prominent position. His book is the first of a series of publications to appear later in the year and it deals with the characteristics of industrial measuring instruments and the performance of automatic controllers. It is the author's opinion that the main purpose of measurement in industry is to provide the practical basis for control, and ultimately to apply automatic means for regulation. To this he attributes the amazing progress in the development of automatic control instruments.

The author thoroughly discusses automatic regulators and the meaning of precision, sensitivity, drift, lag, set, sluggishness, and variance. He also gives the reader some insight into the instrument departments of some leading industrial plants and clearly shows the necessity for a good system of supervision over instruments. In so doing he brings out the fact that any system but one of departmental responsibility would soon lead to confusion and plant operation without machinery.

The book is concise but complete, and contains an extensive bibliography.

The Rhind Papyrus

By Arnold Buffon Chace

(Price $20.00)

THE Rhind Papyrus is the most extensive mathematical treatise written before the sixteenth century B. C. that has come down to us. The papyrus now in existence was written about 1650 B. C. and is a copy of an original written about 1850 B. C. The hieratic writing was transcribed upon a single roll eighteen feet long and thirteen inches wide, but unfortunately, the roll is now broken apart and certain fragments are missing.

Previous works have been written upon this manuscript but this of Dr. Chace's is by far the most complete and elaborate. This edition represents twenty years of labor on the part of Dr. Chace and his collaborators.

Volume I contains a discussion of Egyptian arithmetic, measures, and geometry; a readable translation of the manuscript; a note on the Egyptian

calendar; and a study of the aims of the Egyptian mathematician.

Volume II contains a photographic reproduction of the manuscript; a copy of this in two-color hieratic form; a hieroglyphic transcription; a transliteration of the hieroglyphic into Latin letters; and an English word for word translation. It is interesting to note that these photographs have been instrumental in placing some small fragments now in the New York Historical Society into the papyrus.

We find that the ancient Egyptian was already making arithmetic errors. There are indications in the papyrus of corrections and alterations. However, some errors were undoubtedly made during the copying of the original manuscript.

This work contains an accurate, carefully prepared bibliography of material on Egyptian mathematics. This list prepared by Professor Archibald contains a statement of the nature and value of each important item in the list.

Photochemical Processes and Optical Rotatory Power

(The Faraday Society-Pub., $5.40)

THE subjects for discussion for the April, 1930, and April, 1931, meetings of the Faraday Society, namely: Photochemical Processes, and Optical Rotatory Power, are embodied in two cloth-bound volumes recently added to the Armour Library.

Material on these physical problems is presented by authorities drawn from the best laboratories and colleges of the British Islands and Continental Europe. They have subjected these two topics to a profound and complete analysis based on laboratory and mathematical work which extends over the period of six years since the last general discussions by the Faraday Society of these subjects.

Pocket Table for Cubics

By David Katz

(Price 35c)

CUBIC equations have always been a source of annoyance to the engineer or scientist. Although less common than quadratic equations, they nevertheless do appear here and there in various engineering or physical problems.

The publication "Pocket Tables for Cubics" treats of a theoretical method for solving cubic equations without guesswork and without tedious plotting. This method requires the use of a certain table, just as trigonometric problems necessitate the use of a table of trigonometric functions. Such a table to three significant figures is contained in the "Pocket Tables for Cubics," which also contains a brief outline of the theory involved, and a table of routine steps and formulas to be used in the numerical solution of problems.

Engineering and Inventions

Written by Isaak de Caus
(Translated by John Leak)

THIS book was first written in French by Isaak de Caus, a famous engineer and was translated into English by John Leak. It was printed in 1659 by Joseph Moxon, a mathematician and hydrographer who added typefounding to his callings.

The book describes "New and Rare Inventions of Water-Works shewing the easiest waies to raise Water higher than the Spring. By which Invention the Perpetual Motion is proposed, many hard labours performed and Varieties of Motions and sounds produced."

The author classes motion into two parts: namely, Natural and Accidental. "The Natural Motion is that whereby each Element searcheth and draweth itself towards the place assigned thereto by the Divine Providence in the Creation. The Accidental Motion is that which is moved by any outward Force, different from the First. Now although divers things seem to move contrary to their order, without any external agitation: yet the reason is that their contrary motion is caused to hinder some other greater Accident. As for example, it shall be shewn that the Water to shun Vacuity, mounteth contrary to the ordinary Course thereof, because Vacuity is more repugnant to Nature than the contrary motion of that Element."

Caus preferred to prove his demonstrations by experiment rather than by involving the reader in "a labyrinth of Geometrical Propositions." He believed that the shape of a body determined its buoyant properties. This was caused by a disregard of surface tension.

This book contains numerous woodcuts showing the author's inventions and illustrating his propositions. Illustrations of hydraulic machinery in the form of pumps, woodsaws, drills, clocks, and organs are found throughout the book.

The comparison of the contents of this book with modern scientific advances affords highly interesting reading.

THE ARMOUR ENGINEER

Student Technical Publication of Armour Institute of Technology

MEMBER OF NATIONAL SCHOLASTIC PRESS ASSOCIATION

VOLUME XXIV — MAY, 1933 — NUMBER 4

The Engineer's Leadership

WITHIN a short time the present senior class will enter the world as men among men. Are these men, graduated from an engineering college, able to cope with the problems necessary for world advancement? The entire study of engineering is based upon the ability to analyse and reason. This ability is increased to a maximum during the period spent in an engineering school. The problem of the '33 graduate is to keep himself at the high standard of mental discipline for which he has spent four years at college. If this is done, the graduate engineer will undoubtedly retain his place among the leaders in civilization.

THE GUEST EDITORIAL

The Measure of a Man

DURING the War, an eminent educator, high in the councils of national defense, promulgated a system for rating officers. It consisted of a rating scale to be constructed by each unit commander, based upon the personalities of the officers of his acquaintance. The officer to be rated by this scale was evaluated on the basis of comparison with any two of the integrations on the scale. As no two rating scales were made of the same personalities, there was no fixed relation between these measuring sticks and no standard scale on which all of the others could be calibrated.

You can't measure a man by any such yard stick. The measure of a man is taken only by trial and test and in these strenuous days many of them are falling short of the standards of manhood. I know many Armour men, and if I were making a rating scale for Armour men I can think of one I would put at the top and one at the bottom. Both have brains. Both have ability. Both are fairly successful, but they have fundamentally different ideas of success. One of them has a purely material idea. He measures success in terms of dollars and cents and, to him, the end justifies the means. He is minus zero on my scale. The other is prudent, judicious, has a proper appreciation of his own worth and demands just compensation for his services, but his ideal is one of service, not dollars, and he works for the joy of the working. He has more miscellaneous information than any man I know, more ingenuity, more enthusiasm, more courage. He has done big things because he was not afraid to tackle them and, to my mind, he is one of Armour's most distinguished graduates. If all you are working for is dollars, don't waste time getting a technical education. If you want to be a useful citizen and contribute something to the common good as you make your own way through life, deposit all of your spare time and your spare capital in the best investment a man can make, i.e., an education.

—**Robert Isham Randolph,**
Director of Operations
A Century of Progress.

THE COLLEGE CHRONICLE

NEWS OF THE HONORARY GROUPS AND DEPARTMENTAL SOCIETIES

Tennis

THE Armour Tech tennis team, confronted with a difficult schedule of meets, began its season April 21 by playing Loyola on Armour's courts. Manager Jack Pechman experienced difficulty in drawing up the schedule because many of the schools which Armour has previously met in tennis have dropped their tennis teams this season. However, a total of eleven meets have been arranged between Northwestern University, Chicago, Loyola, DePaul, Lake Forest, Crane and "Y" College.

The probable starting lineup through the season is Captain Streb, Armsbary, McDonough, Cone and Paine. Esbensen, who has shown a marked improvement over last year, may also be used. All of these men have had experience with last year's team and should give Coach Colvert and Armour fans ample reason to be proud.

Boxing

THIS year Armour's boxing team was unable to schedule many meets due to many schools being forced to drop their minor sports. However, had a full schedule been obtained, Armour would have been represented by a fighting team in fighting condition.

Coach Weissman was highly pleased with the turnout of thirty-five men for the squad which was cut, after the school tournament, to the following men: Captain McDonald, Bacci, Behmer, Breh, Babcock, Castanes, Hella, Marcus, Norris, Phillips, Schavilje, Ruben, Fineberg and Suman. Last year's captain, "Sandy" Sandstrom, invaluably aided the team by his work in the Armour corner through the season. The team was more than ably managed by Frank Koko.

In the season's first meet, Armour and West Side "Y" battled to a draw snaring four bouts apiece. For the second meet the Tech fighters made the annual trip to Culver and fought their cadet opponents to a tie. At Culver the team met the usual Culver competition, a smart team in peak condition.

Baseball

WITH a difficult season ahead, the annual Spring cry for baseball candidates was heard by approximately sixty men. Only three of the regulars of last season were not present. With such an imposing squad, great expectancies were raised for the team's achievements.

The pitching squad is led by two veterans, Willis Buehne and George Mayer, both of whom have shown that they still know how to throw a baseball. Among the opponents in the pre-league practice games were two Big Ten Conference teams, the University of Chicago and Northwestern University. The caliber of Armour's team may be shown by the fact that out of four games scheduled with these teams, the Techawks were defeated twice.

The league season began April 21st for the Engineers. As will be remembered, Ar-

mour is now a member of the Northern Intercollegiate Conference and last year, Armour's first, tied for second place in the league.

Basketball

WITH the storing away of their toggery for another year, the Armour quintet went through its traditional final chore, the selection of a captain to lead the next edition of the Tech juggernaut on the hardwood. Ray Pflum, basketeer deluxe, was the unanimous choice for leader, as was expected. Pflum's play throughout the season was nothing short of sensational due to his uncanny eye that seemed to find the range of the hoop from the most difficult angles of the floor. The past season also saw the uncovering of three prize rookies in the personages of Lauchiskis, Dollenmaier, and Laschober. If these three men can repeat their brilliant performances in the next campaign, the Engineers will be able to place their strongest battlefront on the court in several years. Coach Krafft, fully recuperated from his recent illness, will return to his duties as cage mentor succeeding Otto Kuehn, who coached the tri-color the past season.

To top off all this good fortune for the Techawk is the leniency shown him by Old Man Graduation, the grim reaper of athletic teams, who will claim only one regular as one of his victims. That will be when Beemsterboer, the tip-off man of gargantuan proportions, receives his walking papers in the form of a diploma.

Chi Epsilon

CHI EPSILON, honorary civil engineering fraternity, pledged the following men at a smoker at the Triangle house on April 10th:

George A. Nelson, '34.
Bertil W. Laestadius, '34.
George T. Korink, '34.
Nicholas H. Kuehn, Jr., '34.
Carl L. Schermer, '34.

The entire chapter was present at the activities, which lasted the entire evening.

Tau Beta Pi

THE national all-engineering honorary fraternity has been passing through a year of greatly increased activity due to the necessary work involved in the preparations for the 1933 National Convention, in Chicago, next October.

Tau Beta Pi represents the highest scholastic honor attainable in technical education, and as such, it was felt that the pledging ceremony should be of a public nature. Thus, at the school assembly of April 21, the following were pledged:

E. W. Gosswiller, M.E., '34.
C. Huetten, E.E., '34.
I. A. Kolve, M.E., '34.
C. L. Schermer, C.E., '34.
J. E. Schreiner, C.E., '34.
R. W. Suman, M.E., '34.

Salamander

THE honorary fire protection engineering fraternity wishes to announce the pledging of the following juniors:

A. J. Anderson
G. E. Myers

The initiation smoker and banquet for these men will be held in the near future. The annual issue of *The Deflector,* the fraternity publication will be issued at this time.

Pi Tau Sigma

AT A smoker held at the Triangle house on Wednesday, April 5, the following juniors were pledged to Pi Tau Sigma, the honorary mechanical engineering fraternity:

F. E. Headen
I. A. Kolve
C. E. Hillman
J. B. Lukey
L. J. McDonald
E. R. Wood
P. P. Polko
C. E. Dahlgren

After the pledging ceremony, those present, including our faculty guests, indulged in playing ping-pong, bridge, billiards and eating. The pledges, under Ray Nelson, are being prepared for examination and initiation, which will take place in the near future.

Phi Lambda Upsilon

ON FRIDAY evening, March 30th, the honorary chemical engineering fraternity initiated K. L. Hackley, '33.

At a meeting held Monday evening, April 3rd, in the Tau Beta Pi rooms, the following men were pledged:

K. Eberly, '34
R. W. Marty, '34
D. J. Mullane, '34
F. C. W. Noerenberg, '34

Eta Kappa Nu

ETA KAPPA NU announces the initiation of the following men:

A. B. Bronwell, '33
J. D. Fernbach, '33
W. H. Hulswit, '33
S. G. Lehmann, '34
D. O. Schwennsen, '33

Formal initiation was held on Friday, May 5th, and was preceded by an informal initiation on Wednesday, May 3. The ceremonies were attended by all of the faculty. The H. K. N. rooms have been completely redecorated and a more pleasant atmosphere now prevails. A farewell party and dinner dance is being planned for the near future.

Sphinx

THE honorary literary society rewards each year with membership those students that are outstanding in work on the school publications. Great pleasure is taken in announcing the pledging of the following men:

E. G. Avery
J. L. Brenner
D. N. Chadwick
N. E. Colburn
H. W. A. Davidson
R. A. Fleissner
D. L. Jacobson
M. A. Lukas
E. G. Lundin
T. C. Peavey

The annual banquet of Sphinx is to be held in the near future and will climax a year of increased activity of the society.

Pi Nu Epsilon

THURSDAY evening, March 9, Pi Nu Epsilon, honorary musical fraternity, held a smoker at the Beta Psi house. A quiz for all prospective pledges was held at this time, and, as a result, the following men were pledged March 22:

E. G. Avery, M.E., '34
Roy Ekroth, Arch., '34
H. W. A. Davidson, C.E., '34
C. R. Johnson, M.E., '34
J. E. Tamney, E.E., '34
D. E. Traver, M.E., '34

American Institute of Electrical Engineers

ON MARCH 31st, Mr. Brian of the Grigsby-Grunow Company, spoke to the members of A.I.E.E. on the subject, "The Manufacture and Practical Aspects of Radio Vacuum Tubes." Mr. Brian followed through the construction of a typical radio receiving tube.

A very interesting lecture was presented on March 24th, by Mr. R. E. Wulfing, assistant development engineer for the Commonwealth Edison Company, on "Alternating Current Distribution Replacing Direct Current Distribution in Metropolitan Areas." Mr. Wulfing gave a detailed discussion of the important factors of operation, set-up, and interconnection of A.C. networks. Mr. Wulfing predicted that within fifteen years D.C. installing will be completely replaced by A.C.

The annual A.I.E.E. smoker was held March 2, 1933. The evening's entertainment consisted of bridge and the astounding feats of a magician, Mr. Francis Haldane. Professor Freeman, assisted by the magician, astonished everyone, including himself, by causing a bird cage to disappear from his hands before the assembled audience. Refreshments followed and a pleasant evening was enjoyed by all.

American Society of Mechanical Engineers

THE annual student conference of the A. S. M. E. was held in Chicago, Friday and Saturday, April 28 and 29. Delegates from all the schools in this region having student branches were present. Friday morning was devoted to organization and the reading of papers prepared by student delegates. Friday afternoon saw the visiting of several plants in inspection trips. More student papers, a trip to the Century of Progress grounds, and a banquet helped make Saturday a full day. Everyone attending the convention was more than delighted with the whole program.

Western Society of Engineers

AT THE meeting of the Armour branch on Friday, April 7th, Mr. Monroe Adney Smith, Jr., of the United States Gypsum Company, delivered a very interesting talk on acoustics. Mr. Smith, who is a graduate of Armour, illustrated his talk with actual pictures of sound waves and their actions, together with some modern applications of acoustical research.

On April 28th, the society heard a talk on Construction Joints given by Mr. Barker of the Portland Cement Association. Arrangements will be made in the future for another smoker and general get-together.

Alpha Chi Sigma

THE professional chapter of Alpha Chi Sigma held a meeting on March 7th at the Chicago Engineers' Club, 314 South Federal Street, at half past six in the evening. The speaker was Dr. W. C. Allee, professor of zoology at the University of Chicago, who is well known as a writer and lecturer. His topic was "Unbalances in Nature."

Prior to this year, Mr. Van Dorn of the Central Scientific Company, district counsellor of the fraternity, lived at Madison, Wisconsin, but as he now lives in Chicago the members of the Armour chapter are kept keyed up by frequent visits.

Fire Protection Engineering Society

DURING the past few months the F.P.E.S. has held a number of very interesting meetings and a highly success-

ful smoker. This latter was the climax of the school year for the "Fire Protects" with the largest crowd in many years attending. Entertainment was furnished by Prof. Martineck, a skilled professional magician. The honorary and alumni members in attendance included Mr. J. V. Parker, Professors Finnegan, Robinson, and Norway, and Messrs. Beckwith and Parker.

Mr. Roberts, of the Plymouth Cordage Co., presented an interesting sound-movie of rope making at a recent society meeting held in conjunction with the A.S.M.E.

Mr. Quakenboss, of the Western Factory Insurance Association, presented a talk on "Modern Sprinkler Equipments and Risks," at a more recent meeting.

American Chemical Society

AT THE last monthly meeting of the American Chemical Society, held at the Midland Club, Dr. Clyde Harold Bailey, professor of agricultural biochemistry at the University of Minnesota, delivered an address on "Physical and Chemical Methods in Applied Biochemistry."

The chief of the Chemical Warfare Division of the United States Army, General Gilchrist, a visitor at the meeting, was called on to give a short talk. He told of the effect of present economic conditions on chemists and gave an opinion on the use of chemicals and poisonous gases in warfare.

After the adjournment of the main session, various group meetings in inorganic, analytical, organic, biochemical, and physical chemistry as well as chemical education were held.

Armour Architectural Society

THE first get-together of the year, for the entire Architecture Department, was held in the form of a smoker in the Club Room of the Art Institute. This smoker was intended as a reception for our new president, Dr. W. E. Hotchkiss. Most of the faculty members were also present. The entertainment consisted of a series of highly humorous skits, presented by each of the four classes. They were satires on recognizable happenings and life on the campus.

The evening ended in the traditional manner with the serving of refreshments.

Scarab

ROY A. EKROTH has been elected "World's Fair" President of Edfou Temple of Scarab, architectural fraternity. The other officers chosen are B. R. Buchhauser, Vice-President; L. W. Davidson, Treasurer; R. B. Tague, Secretary; and R. Schwab, Sergeant at Arms. The retired President, T. H. Irion, is now Director of Activities of the national fraternity.

Arrangements are being made by the new officers for the annual convention of Scarab, which will be held in Chicago during the World's Fair.

ALUMNI NOTES

NEWS OF ARMOUR ALUMNI ASSOCIATION AND OF ARMOUR GRADUATES

Meeting of Alumni Officers

AT THE last business meeting of the Board of Managers and Advisors held at the Engineers' Club April 7th at 6:30 P.M. the following items of business were decided:

The dues were lowered to one dollar per year. The Reunion Banquet is to be held on June 2nd, at which time President Hotchkiss will be introduced to the Alumni. Also, the 25th year reunion of the class of '08 will be held.

It was decided to issue a quarterly paper to keep the Alumni informed of what progress the Institute is making, as well as to give general news items concerning the Alumni. The cost of publication of the quarterly will be about $75.00 for one issue of 4,200 copies. The yearly dues of one dollar includes the quarterly. Dues are payable to Prof. D. P. Moreton, Armour Institute of Technology.

Mr. P. G. Heuchling is the editor of the new venture. All information concerning the Alumni affairs may be sent to him.

President J. Schommer made the following appointments:

Mr. A. L. Eustice is chairman of the Student Loan Fund Committee. He supersedes Mr. Louis Byrne, who has done an excellent job for eighteen years as chairman.

Mr. H. W. Martin is the chairman of the Finance Committee.

Mr. R. N. Friedman is chairman of the Faculty and Student Committee.

Mr. N. B. Cole is chairman of the Activities, such as banquets, dances, etc.

Mr. M. A. Smith is chairman of the committee on Industrial Relations.

President Schommer requests that June 2nd be held open by the Alumni, for on that day the Reunion Banquet will be held. The place will be announced later.

Roger F. Waindle, '32, is now located with the Johnson Company, wholesalers of ventilating equipment.

Peter Venema, '32, is with the Reliance Dental Mfg. Co.

John H. Sweeney, '24, is in the insurance business with W. A. Alexander & Co.

John B. Allen, '23, who has been engaged in building and architecture for the Presbyterian missions in Cameroon, West Africa, died on Oct. 1, 1932.

A. Mueller, '32, is in Detroit, Michigan, and working for the Michigan Inspection Bureau.

C. Robin, '32, is located somewhere in the State of Alabama doing U. S. Government work.

J. A. Bechtold, '30, is with the St. Louis Inspection Bureau at St. Louis, Mo.

Frank James, '31, is working for the Kentucky Actuarial Bureau at Paducah, Kentucky.

TECHNICAL ABSTRACTS

CONDENSATIONS OF LEADING ARTICLES IN THE TECHNICAL PERIODICALS WITH PERMISSION OF AUTHORS AND PUBLISHERS

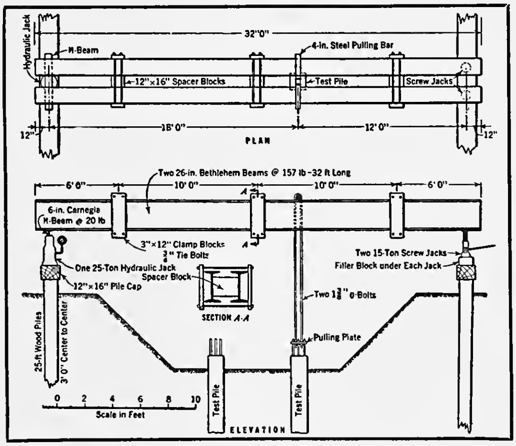
Holding Down Power of Concrete Piles

By John H. Gregory, Robt. A. Alton, and James H. Blodgett.

(From *Civil Engineering* February, 1933)

PILES are commonly thought of as providing a means of supporting loads and of offering resistance to settlement. There are times, however, when they offer a satisfactory and economical method of holding down a structure subject to hydrostatic uplift. A test was made at Columbus, Ohio, to determine the "holding down power" of precast reinforced concrete piles, so that a comparison of cost could be made between two designs for storm stand-by tanks, one with a heavy bottom and the other with a lighter reinforced concrete bottom held down by piles.

At the side of the tanks the ground has an elevation of 11 ft. above ordinary low water on the Scioto River and is subject to overflow at highwater. Two washborings for data were made adjacent to the excavation which was carried to the approximate elevation of the under side of an assumed reinforced concrete bottom for the tanks, so that the test piles could be in actual material. The ground consisted mainly of sand and gravel.



Details of testing apparatus

Eight precast reinforced concrete piles were used. They were all of 14 sq. in. uniform cross section with 18 in. tapered points. Above the tapered point, four were 15 ft. and four 20 ft. After the piles were cured and surfaced, they were driven with a 3,000 lb. ram. The average time between making and driving was 35 days. The first pile was tested 7 days after driving and the last 29 days after.

Details of the testing apparatus are shown in the accompanying figure. The two girders acted together as a lever, the two screw jacks as the fulcrum, and the hydraulic jack as the lifting force.

A gage on the hydraulic jack indicated the pressure exerted by the jack in tons. The screw jack kept the girders level and compensated for the compression of the timber caps.

The dead load of the testing apparatus was determined, then the horizontal distances from the hydraulic and screw jacks to the center of the pulling bar were measured and last, a vertical rod was attached to the pile and read with a wye level.

A constant pressure of 100 lbs. per sq. ft. of surface area was maintained on the pile for four hours. The pressure was increased for each four hour period by an increment of 100 lbs. per sq. ft. until some movement of the pile was detected.

The "holding down power" of piles due to frictional resistance varied from 507 to 722 lbs. per sq. ft. The cost of the test, exclusive of engineering, was $6,370.

Proper Size Wrenches for Tightening Nuts on Bolts

(From *Power,* March 1933)

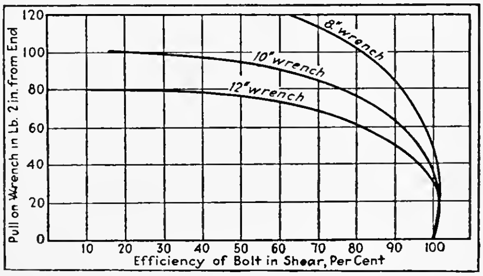
IN "Contact" of the New England Power Association there appears an article, "Care Important in Tightening Tower Bolts," by C. A. Booker, which, although dealing with bolts in transmission towers, is applicable to bolts in any application where they are stressed after being tightened. It was found that bolts in tower crossarms failed during the application of test loads. An inquiry among the workmen who assembled the towers developed the fact that the nuts had been tightened with wrenches which were too long. This resulted in high initial stress in the bolts and premature failure when the structure was loaded.

With this conclusion as a starting point, an attempt was made to analyze the reasons for bolt failure. About 85 per cent of the effort used in tightening the nut is wasted in overcoming the friction of the surfaces in contact, and only about 15 per cent of the effort is expended in actually tightening the nut. If friction were entirely absent, a small boy could, without difficulty, draw a nut up so tight that a 5/8 inch bolt would pull apart at the root of the threads, since a force of only 25 pounds applied at the end of a 10 inch wrench is all that is necessary to cause this failure. The large amount of effort needed to overcome friction, as related to the effort necessary to tighten the nut, also explains why after the nut is tightened it does not immediately back off the bolt when the pressure on the wrench is released. When two structural members are to be bolted together so as to transfer a stress from one to the other, this is generally accomplished by having the bolts so placed as to act in shear. The holding power then is developed partly by friction of the bolt against being cut off by the scissors action of the two surfaces. Studies of the holding power of bolts under varying tightness of the nut resulted in the curves that indicate there is a happy medium in the tightness to which a nut can be drawn in order to achieve best results.

The following sizes of wrench will develop about the ideal tension in the ordinary bolt if taken up with a pull of about 75 pounds, that is, just what a husky lineman would call "snug":

Bolt sizes (Inches)	Wrench length (Inches)
1/2	7
5/8	10
3/4	14
1	20

In the case of a bolt working in tension, such as an anchor bolt on a concrete footing, it makes no difference in the ultimate holding capacity of the bolt what initial tension may be applied. So long, of course, as this tension is within the elastic limit of the steel, additional torque may be developed by using the longest wrench available on bolts exceeding one inch in diameter.



Graph showing ratio of pull on wrench to efficiency

Heating Homes by Reversed Refrigeration

(From *Fuel Oil Journal,* March 1933)

REVERSED refrigeration may become an important method of heating and cooling if tests now being conducted by the research laboratory of Westinghouse Electric & Mfg. Co., East Pittsburgh, prove successful. The reversed refrigeration cycle, long familiar to students of thermodynamics, is directly opposite to that employed by the compression system of refrigeration used in many electric refrigerators. Instead of drawing heat from an enclosed space, as in a refrigerator, heat is pumped or transferred from the outside atmosphere into the building to be heated.

To understand how heat can be taken from cold winter air, the outside atmosphere may be likened to a large reservoir of air that, although relatively colder than the temperature required for human comfort, contains vast quantities of heat. As no heat is present only when a temperature of 460 degrees below zero F., called absolute zero, is reached, there is a vast supply of heat available in winter air.

The illustration shows how the reversed refrigeration cycle operates. Vapor from the evaporator is compressed, causing its temperature to increase. When the gas flows through the condenser it condenses, becomes a liquid, and liberates heat. On reaching the expansion valve the pressure of the liquid refrigerant is so reduced that it boils and vaporizes. The evaporating process makes the evaporator colder than the outside air. Heat therefore flows from the warmer outside air to the refrigerant and the vapor is again drawn off by the compressor, thus repeating the cycle.

Although a major objection to using the reversed refrigeration cycle for house-heating has been the excessive size of apparatus required, Westinghouse engineers are using a compact, six-ton compressor to pump heat in or out of a brick house in which the experiments are being conducted.

The Geared Motor-Reducer

By Paul W. Arnold

(From *Factory Management and Maintenance,* March 1933)

INDUSTRY has found and is rapidly adopting a new piece of power transmission equipment—the combination of a speed reducer and an electric motor, built as a single unit. Speed reducers were developed as separate, inclosed units because of the need for something better than open gearing. To combine a separate speed reducer with a source of power it is necessary to mount the two units on some sort of a base and connect them with a flexible coupling. The combination unit eliminates the sub-base and intermediate coupling, and the necessity of mounting and lining up two units.

The advantages of the geared motor-reducer over the separate units may be concisely stated as:

1. Lower first cost.
2. Lower installation cost.
3. Less floor space required.

There may be other minor advantages but these three are of such importance that they cannot be disregarded. The savings possible must be considered in new power drive and machine layout projects, in the design of new equipment, and in the modernization of old equipment.

It is impossible to give a definite comparison of the first cost of geared motor-reducers and the cost of separate reducers plus motors, bases and couplings, because of the wide variation in the types that are on the market. Any general statement that is made can be disproven at least in part. However, to give a rough idea of comparative first costs the chart shown in Figure 1

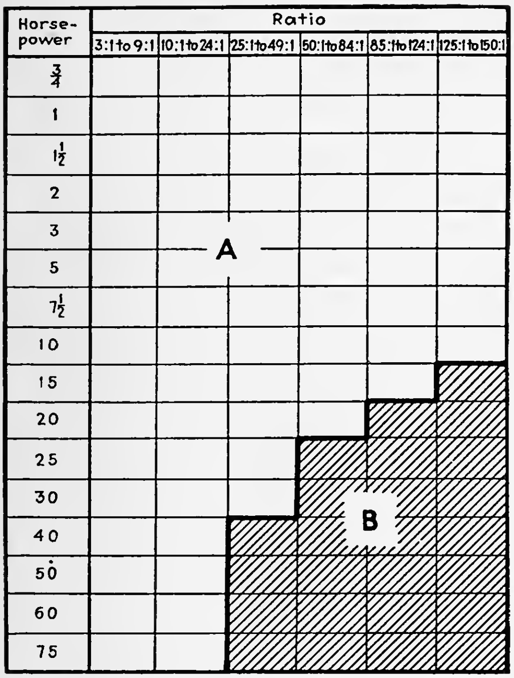


Figure 1—If the desired horsepower rating and reduction ratio fall in area *A* it is probable that the first cost of a geared motor-reducer will be less than that of a separate motor and speed reducer. When the horsepower and ratio fall in area *B* the costs will be about the same, or the motor-reducer may be slightly higher

has been prepared. If the required geared motor-reducer falls in area *A* it is fairly safe to assume that it will be lower in first cost than the separate units. It if falls in area *B* the costs may be about the same or possibly slightly more for the geared motor-reducer.

The geared motor-reducer prices used in making this comparison are a fair composite of the published prices of several types. This price has been compared with the average price of conventional herringbone or helical speed reducers plus a fair addition for the base, coupling, and mounting. If the comparison had been made against worm-gear reducers it is quite possible that for small units and low ratios an occasional saving might be shown for the separate units. If estimates are to be made with absolute certainty the actual prices of the separate and combined units must be compared.

Installation cost of a geared motor-reducer is lower than that of separate units. Since it is delivered as a complete unit, the installation cost is about the same as that of a motor alone. Separate motors and speed reducers may be received completely assembled and mounted on a base, but when installed a more elaborate foundation is required. It is also desirable to check alignment and correct any error that may have been caused by shipment or improper installation. If the units are received separately the installation work and cost are greater.

It is as difficult to give definite figures on space saved by geared motor-reducers as on first cost, because of the variations in construction and design of both the combined and the separate units. A fair average, however, would be about 25 per cent. Frequently the difference in the shape of the space required works out to the advantage of the geared motor-reducer.

Initial and Final Dam Heights

By E. H. Burroughs, M. Am. Soc. C. E.

(From *Civil Engineering* January, 1933)

FINANCING any water storage project is usually a difficult problem. In this article methods are indicated for enlarging the capacity of the reservoirs when required by increased storage demand, and when the funds are available to cover the cost.

In many cases it is not economically feasible to construct a dam to the maximum height to provide for future need. It is possible, however, to construct a dam sufficient for present need and to make allowances for future additions.

Most existing masonry dams can be adapted or reconstructed to provide for some method of increased poundage without reduction of their safety factors. The three methods commonly used are: adding

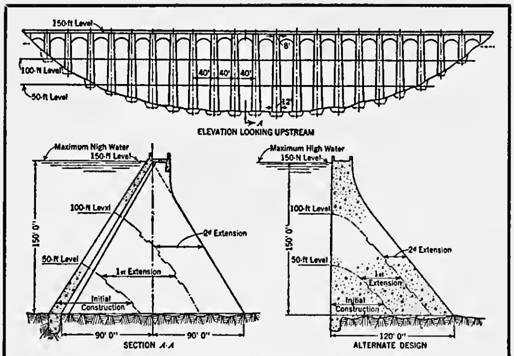


FIG. 1. METHOD OF RAISING A HYPOTHETICAL DAM

flashboards to the spillway crest, adding crest gates, or adding to the initial construction a concrete structure that will reinforce the existing dam and carry the additional water load. Flashboards are the commonest and cheapest for obtaining a very limited increase in reservoir capacity.

Crest gates simply provide for permanent storage and head all or part of the available freeboard between the present level of the spillway crest and the maximum flood level. This increase is usually of greater proportion on a low dam than on a high one, but is always of great economy and immediate availability. Automatic crests permitting free spillway discharge at times of high water may be economically added to the initial structure at any time they are required. These gates can be adjusted to give a very close control over the pond level.

Where the height of a gravity dam must be raised more than is permissible with automatic crests, downstream buttresses supporting and upstream water-bearing face may be used. Another method consists of joining to the downstream face an additional section.

In the case of the Ambursen type, the additional height is customarily provided by extending the original buttress downstream and by adding the conventional flat-slab, water-bearing deck to whatever new crest height may be indicated.

The great economic saving that may be effected through designing dams to be later raised may be seen by a study of the accompanying figure. The initial 50 feet costs 16% of the final cost and holds 5% of the final capacity; the first extension costs 44% and holds 23%; and the final extension costs 40% and holds 72%.

Cost savings depend largely on the intervals between construction of each extension.

X-Raying Welded Joints Four Inches Thick

By R. E. Hiller

(From *Engineering News-Record,* Feb. 16, 1933)

UNTIL recently much skepticism has been evident with regard to the use of welding in construction work, because there was no way of being certain of the quality of the work. For some time, equipment has been available for examining welded joints when they were less than 2¼ inches thick.

Now comes the development of a new large X-ray tube whereby welded seams in plates over 4 inches thick are successfully examined. Formerly tubes could be operated at 200,000 volts in examining welds 2¼ inches thick, while for thicker seams they were operated above their capacity with injury to the tube. The new tube is capable of being operated at 300,000 volts with the resultant increase in the thickness of steel that can be penetrated.

The new tube is 4 feet long and has a bulb at the center 8 inches in diameter all of pyrex glass ¼ inch thick, whereas the old tube was $\frac{1}{16}$ inch thick. The electrode arms are longer than in the smaller tube. The water-cooled target is a disk of tungsten steel secured in a copper block. The cooling water, at a pressure of 50 pounds per square inch, is connected to a radiator having a

thermostatic control which automatically cuts off the power when the water becomes too hot.

The particular apparatus described has an equipment room 10x16x16 feet, a control booth 4x4½ feet, with ⅛ inch thick lead lining, a tube box 9x3¾x4 feet, with $\frac{7}{16}$ inch thick lead lining. This lining is for protection from X-ray radiations.

In using the apparatus, the welded seam is placed before an aluminum window in the tube box, 5x5x$\frac{1}{16}$ inches thick, from which the powerful rays issue. For a long seam, as on a pipe or steel drum, the examination is done in sections about ten inches in length, the time of exposure depending upon the thickness of plate, and ranging from 10 seconds for a 2½ inch plate to 50 minutes for a 4½ inch plate. As each section is examined, the vessel is moved along in front of the window until the next section is in place for examination.

Use of similar apparatus on recent heavy welding has proven the reliability of the results it gives.

ENGINEERING PROGRESS

NEW DEVELOPMENTS AND DISCOVERIES IN SCIENCE AND INDUSTRY

Draft Gage Alarm

A SENSITIVE electric alarm system for draft gages has been developed recently. It is made in either the straight-line or the dial type pointer draft gage for minus, plus, or differential readings, and for either high or low draft alarm. The transformer to be used is furnished for either 220 or 110 volts. Dry cells are used for other than alternating current.

The system consists of a transformer, a bell, and a mercury chamber and contact rod comprising the switch. The chamber is composed of hard fiber which is partly filled with mercury. The mercury is covered with oil for sealing the electric arc and also for sealing the mercury against oxidation. The electric contact rod is suspended on the beam of the gage, on a knife edge bearing, and is adjustable so as to ring the bell at any point of the scale, within a variation not to exceed 0.01 inch.

Solution Feed Equipment

A NEW device for feeding solutions at a constant rate possesses simplicity, corrosion resistance, constancy of feed and complete accessibility of all parts for cleaning or replacement. A siphon is mounted on a parallel motion hinge, the free end of which is carried on a float in the tank from which the solution is fed. The solution flows to the feeding tank under the control of a float valve, which throttles the inflow of solution to the rate at which the siphon is feeding. The rate of feed depends on the difference in level between the solution in the tank and the outlet end of the siphon. A convenient screw is provided for adjustment to the desired flow. The output of the siphon is caught in a glass vessel formed to serve as both a funnel and a trap. When the supply to the feeder is stopped, this trap seals the open end of the siphon and causes the siphon to be kept primed in readiness to commence feeding as soon as the supply to the apparatus is restored. All parts of the apparatus can be dismantled for cleaning with nothing other than a screw driver. As accessory apparatus, an automatic valve for switching the feed from one supply tank to another and a pressure filter can be used.

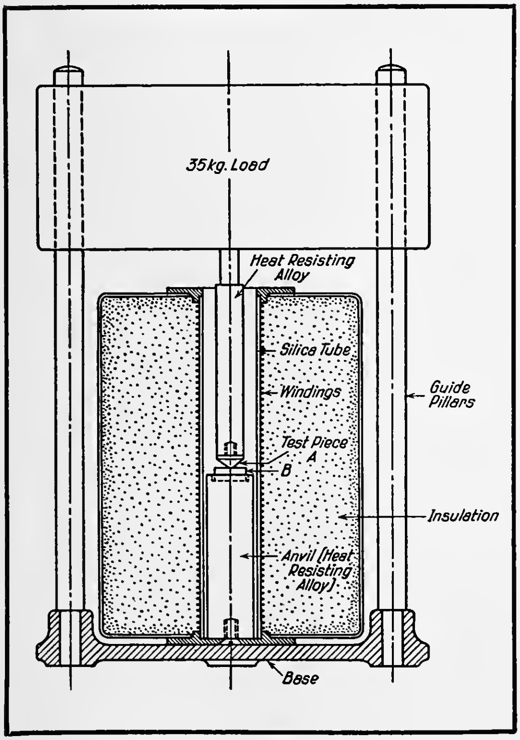
Measuring Hardness at High Temperatures

A METHOD for determining the true hardness of metals at high temperatures, which enables the results to be expressed as Brinell numbers, has been developed in England.

The sample to be tested is made into the form of a small cone with an included angle of 120°. This rests on an anvil and is submitted to a load of 35 kg. for a period of ten days. The anvil, cone, and plungers are surrounded by a small electric resistance furnace and can be maintained at any desired temperature up to 1150°C. (2100°F.), the temperature being controlled by any of the usual commercial devices. The anvil cap is made from a hard heat-resisting metal containing approximately 60% nickel,

20% chromium, and 7.5% aluminum. Provision is made for maintaining an inert atmosphere.

Under the combined effects of pressure, time, and temperature, the apex of the cone flattens out and the area of contact between it and the anvil face steadily increases. Equilibrium is generally reached in 100 hours, but generally the test is maintained for ten days in order to insure accuracy of results. The hardness number is found by dividing the area of the flattened surface on the cone in square millimeters into the load in kilograms. Above 700°C. (1300°F.) practically all metals (with the exception of cemented tungsten carbide and a few peculiar alloys which depend for their hardness upon the presence of compounds of aluminum with a metal of the iron group) appear to have a Brinell hardness considerably less than 10.0.



Apparatus for testing hardness

Measuring Wind Stresses in a Skyscraper

In ACCORDANCE with its policy of serving the building field, the American Institute of Steel Construction has been conducting research for several months, to find the effects of wind on tall buildings. The Empire State Building, which was selected for the tests, is particularly well suited to such research, as it is symmetrical about its horizontal and vertical axes, and the wind has an unobstructed sweep on the upper part of the building.

The method used is the familiar one of measuring the change in length of a member due to a stress, and from this data determining the stress; the instruments used here actually give the stress directly. Measurements of deformation are made by strain gauges placed on tower columns and on girders. The upper end of a ½ inch round steel bar 50 inches long is welded to the column, and the lower end is connected to the gauge, which is in turn connected to the column. The gauge measures the change in length in fifty inches due to tension or compression in the column, and the dial shows the stress in pounds per square inch. The amount and kind of stress in girders is given by similar instruments.

It is necessary to know not only the stress in members, but to know the amount of wind causing this stress. Accordingly, the pressure on the windward side and suction on the leeward side of the building are measured through pipes running from the outside walls to U-tubes filled with colored water, which show on a graduated scale the difference between exterior and interior pressures.

In addition to stresses in members and wind pressures on the building, it is desired to know the amount of sway of the building and the period of vibration of the sway. A vertical telescope instrument, a collima-

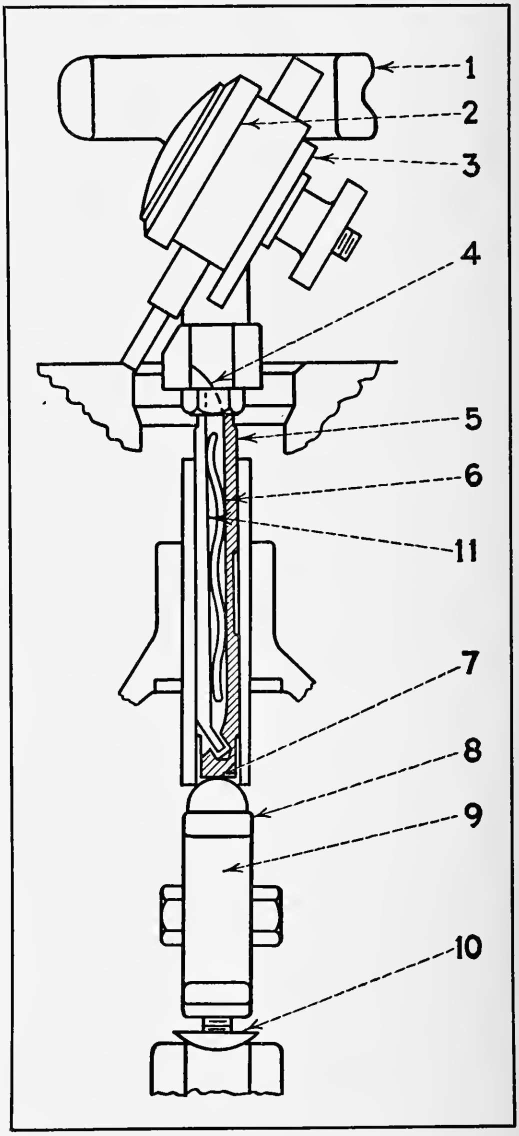
tor, placed at the sixth floor and pointed up through a fire shaft toward an illuminated target in the shaft at the eighty-fifth floor, is used for this measurement. Thus a line of sight 900 feet long is used to measure the sway. An anemometer on the tower records wind velocities, which are very high at that elevation.

All readings, except that on the collimator, are recorded simultaneously by electrically operated moving picture cameras placed at the various recording stations in the building and controlled by a single switchboard.

Valve Seating "Concentrometer"

A TOOL which shows whether the angular seat of a gas engine valve is concentric with the axis of the valve guide has been developed. The tool is adaptable to both intake and exhaust value seats. The various parts of the tool are as follows:

1. Indicator housing.
2. Precision indicator having a special attachment.
3. Indicator swivel supporting the indicator which can be adjusted to any desired angle.
4. Indicator pilot joint which makes a one-piece construction between the pilot and the indicator housing.
5. Indicator pilot which is the three point bearing member of this instrument. It is round and has a recess in the center. One side is flattened longitudinally and the other slotted to carry a spring. The two edges of the flattened side form two of the three bearings while the spring forms the other.
6. Indicator pilot spring which maintains an outward pressure on the indicator pilot shoe (#7). These two parts form the adjustable third bearing point of the pilot.
8. Indicator depth control pliers which are held rigidly open by the indicator pilot expansion spring (#9).



Valve Seating Concentrometer

The operation of this tool is as follows: The depth control pliers are placed in position so that the centering and depth control adjusting screw is located in the valve tappet guide hole and the hardened ball in the lower end of the valve guide. Last the indicator pilot is slowly pushed into the valve guide until its base rests on the steel ball of the depth control pliers.

The Quest for Gold

IT SEEMS a far cry from the ancient burro and dilapidated pan of the early gold prospector to the modern electrical apparatus, yet both represent mile-stones in the perpetual quest for the precious and elusive yellow metal.

The latest development is a device called an ore detector. This instrument will be used to locate electrically conductive deposits of gold which may occur at depths not exceeding some five to ten feet. Only two men are required to operate the apparatus, which consists of a power unit, a receiver unit, and an exploring unit.

The power unit comprises a vacuum tube oscillator and an amplifier, while the receiver unit consists of an inductance bridge and vacuum-tube amplifier. Headphones are used as null indicators.

In operation, the bridge is energized by a 2000-cycle sinusoidal current, the power-level of the oscillator-amplifier being adjusted to meet the requirements of depth penetration. Following this the receiver amplifier is set for the desired gain, and the bridge brought to precise balance by appropriate resistance and inductance controls. The condition of balance is indicated by silence in the headphones.

If the exploring coil is moved over the ground, and a conductive body comes within the magnetic field of the coil, the eddy currents set up in the conductive mass will reduce the effective inductance and the exploring coil, which serves to unbalance the bridge. This condition will be indicated by the appearance of a shrill note in the headphones, the intensity of the sound depending on the degree of bridge unbalance. A change in the inductance of the exploring coil of one part in a million may be detected readily in this manner.

While this ore detector was designed primarily to provide means for locating relatively shallow veins and placer deposits of gold, it should be understood that any conduct of electricity will give a similar reaction with the instrument. The magnitude of the response will depend on the physical properties of the disturbing mass, its conductivity and depth, and the electrical constants of the surrounding media.

CONTRIBUTORS' PAGE

BRIEF BIOGRAPHICAL SKETCHES OF OUR AUTHORS

MR. R. S. KENRICK is an Armour graduate in Electrical Engineering of 1922. His article, "Economic Stability, Fallacy or Future Possibility," was written after long observance of general conditions in his capacity as Market Survey Editor, A. C. Nielsen Co., Chicago, Mr. Kenrick analyzes the situation capably and offers solutions for a number of perplexing problems. This is the last of two articles written by Mr. Kenrick.

PROF. WILLIAM WHITE COLVERT, associate professor in the department of Physics, and author of "X-Ray Absorption, Measurements, and Applications," received his A.B. degree from Cumberland University at Lebanon, Tenn., in 1917. In 1919 he received his M.A. from the same institution after which he became an instructor in the department of Physics at the Armour Institute of Technology. Prof. Colvert is also a member of the Sigma Xi honorary scientific fraternity.

PROF. HARRY H. BENTLEY, author of "Perspective and Entourage," received his B.S. degree from the Massachusetts Institute of Technology in 1908. He studied and traveled in Europe in 1911 and 1912 and again in 1923 and 1924. At the present time he is assistant professor of Architectural Design at the Armour Institute of Technology, and is a member of the American Institute of Architects.

BERNHARD H. E. LOESCHE, author of "Air Conditioning for Radio Broadcasting Studios," is a senior in the department of Civil Engineering, and a graduate of Tilden Technical High School. Loesche is a member of Tau Beta Pi fraternity.

THE frontispiece is the photograph of a prize winning sketch drawn by Eugene Voita, '25. A tower following Mr. Voita's sketch has been constructed in Baltimore, Md.